

CHAPTER IV - SUMMARY OF TROPICAL CYCLONES

1. GENERAL RESUME

a. WESTERN PACIFIC

In 1976 the number of tropical cyclones remained below the long term average. There were 25 numbered tropical cyclones in the JTWC area of responsibility, all of which progressed to tropical storm or typhoon intensity (Table 4-1). Although the number of tropical cyclones was the same as last year's total, the occurrence of named storms during 1976 increased by 25% (Table 4-2). Of the 25 storms, 14 attained typhoon intensity, including four super typhoons. The month of March was the only month without a numbered cyclone, while three months (February, March & December) were without a typhoon (Tables 4-2 and 4-3).

Table 4-4 indicates the number of tropical cyclone formation alerts issued by year. During 1976 there were 34 alerts, of which 25 developed to tropical storm or typhoon intensity. All storms of 1976 were preceded by a formation alert. The average lead time between the issuance of a formation alert and the first warning was 17.8 hours, with a minimum of 3.5 hours for Louise and a maximum of 64 hours for Marge.

The storm season had an early debut with typhoon Kathy forming in January. The near equatorial trough was firmly established by April and maintained itself throughout most of the remainder of the year. An exception was late September and most of October, when the westerly flow along the equator gave way to easterly trades.

TABLE 4-1.
1976 TROPICAL CYCLONES

PACIFIC AREA									
CYCLONE	TYPE	NAME	PRD OF WRNG	CALENDAR DAYS OF WARNING	MAX SFC WIND	MIN OBS SLP	NO. OF WARNINGS TOTAL	AS TY	DISTANCE TRAVELED
01	TY	KATHY	28 JAN-02 FEB	6	80	969	22	9	1966
02	TS	LORNA	27 FEB-01 MAR	4	35	---	13	--	806
03	TY	MARIE	03 APR-14 APR	12	115	929	44	32	955
04	TS	NANCY	25 APR-02 MAY	8	55	984	27	--	1279
05	TY	OLGA	12 MAY-27 MAY	16	100	934	60	8	2443
06	STY	PAMELA	14 MAY-27 MAY	14	130	921	52	40	2570
07	TY	RUBY	23 JUN-04 JUL	12	120	934	45	24	2798
08	TY	SALLY	24 JUN-03 JUL	10	115	923	37	23	2981
09	STY	THERESE	11 JUL-20 JUL	10	135	903	37	29	2290
10	TS	VIOLET	21 JUL-25 JUL	5	55	---	20	--	650
11	TS	WILDA	22 JUL-24 JUL	3	45	992	9	--	898
12	TY	ANITA	23 JUL-25 JUL	3	65	979	9	2	864
13	TY	BILLIE	03 AUG-10 AUG	8	125	914	31	17	1854
14	TS	CLARA	05 AUG-07 AUG	3	40	---	7	--	263
15	TS	DOT	18 AUG-23 AUG	6	50	989	18	--	1408
16	TS	ELLEN	20 AUG-24 AUG	5	45	993	15	--	1243
17	STY	FRAN	03 SEP-13 SEP	11	130	913	41	26	2616
18	TS	GEORGIA	09 SEP-15 SEP	7	40	992	26	--	1325
19	TY	HOPE	14 SEP-17 SEP	4	70	981	15	6	1604
20	TY	IRIS	14 SEP-21 SEP	8	75	967	29	11	756
21	TY	JOAN	19 SEP-24 SEP	6	70	---	20	2	1368
22	HR	KATE	21 SEP-02 OCT	(CENTRAL PACIFIC HURRICANE CENTER)					
23	STY	LOUISE	30 OCT-07 NOV	9	140	895	35	25	2754
24	TS	MARGE	06 NOV-11 NOV	6	60	977	21	0	1836
25	TS	NORA	03 DEC-08 DEC	6	45	992	21	--	456
26	TS	OPAL	09 DEC-10 DEC	2	35	996	7	--	338
1976 TOTALS				131*			661	254	

INDIAN OCEAN AREA

TC	20-76	29 APR-02 MAY	4	50	---	7	--	403
TC	22-76	02 JUN-03 JUN	2	40	---	3	--	163
TC	23-76	10 SEP-11 SEP	2	40	---	5	--	324
TC	25-76	15 OCT-17 OCT	3	50	---	6	--	372
TC	30-76	30 DEC-02 JAN	4	55	---	7	--	511
1976 TOTALS			15*			28	--	

*OVERLAPPING DAYS INCLUDED ONLY ONCE IN SUM

TABLE 4-2 FREQUENCY OF TROPICAL STORMS AND TYPHOONS BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
AVERAGE (1945-58)	0.4	0.1	0.4	0.5	0.8	1.3	3.0	3.9	4.1	3.3	2.7	1.1	22.0
1959	0	1	1	1	0	0	3	6	6	4	2	2	26
1960	0	0	0	1	1	3	3	10	3	4	1	1	27
1961	1	1	1	1	3	2	5	4	6	5	1	1	31
1962	0	1	0	1	2	0	6	7	3	5	3	2	30
1963	0	0	0	1	1	3	4	3	5	5	0	3	25
1964	0	0	0	0	2	2	7	9	7	6	6	1	40
1965	2	2	1	1	2	3	5	6	7	2	2	1	34
1966	0	0	0	1	2	1	5	8	7	3	2	1	30
1967	1	0	2	1	1	1	6	8	7	4	3	1	35
1968	0	0	0	1	1	1	3	8	3	6	4	0	27
1969	1	0	1	1	0	0	3	4	3	3	2	1	19
1970	0	1	0	0	0	2	2	6	4	5	4	0	24
1971	1	0	1	3	4	2	8	4	6	4	2	0	35
1972	1	0	0	0	1	3	6	5	4	5	2	3	30
1973	0	0	0	0	0	0	7	5	2	4	3	0	21
1974	1	0	1	1	1	4	4	5	5	4	4	2	32
1975	1	0	0	0	0	0	2	4	5	5	3	0	20
1976	1	1	0	2	2	2	4	4	5	1	1	2	25
AVERAGE (1959-76)	0.6	0.4	0.4	0.9	1.3	1.6	4.6	5.9	4.9	4.2	2.5	1.2	28.4

TABLE 4-3 FREQUENCY OF TYPHOONS BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
AVERAGE (1945-58)	0.4	0.1	0.3	0.4	0.7	1.1	2.0	2.9	3.2	2.4	2.0	0.9	16.3
1959	0	0	0	1	0	0	1	5	3	3	2	1	20
1960	0	0	0	1	0	2	2	8	0	4	1	1	19
1961	0	0	1	0	2	1	3	3	5	3	1	1	20
1962	0	0	0	1	2	0	5	7	2	4	3	0	24
1963	0	0	0	1	1	2	3	3	3	4	0	2	19
1964	0	0	0	0	2	2	6	3	5	3	4	1	26
1965	1	0	0	1	2	2	4	3	5	2	1	0	21
1966	0	0	0	1	2	1	3	6	4	2	0	1	20
1967	0	0	1	1	0	1	3	4	4	3	3	0	20
1968	0	0	0	1	1	1	1	4	3	5	4	0	20
1969	1	0	0	1	0	0	2	3	2	3	1	0	13
1970	0	1	0	0	0	1	0	4	2	3	1	0	12
1971	0	0	0	3	1	2	6	3	5	3	1	0	24
1972	1	0	0	0	1	1	4	4	3	4	2	2	22
1973	0	0	0	0	0	0	4	2	2	4	0	0	12
1974	0	0	0	0	1	2	1	2	3	4	2	0	15
1975	1	0	0	0	0	0	1	3	4	3	2	0	14
1976	1	0	0	1	2	2	2	1	4	1	1	0	15
AVERAGE (1959-76)	0.3	0.1	0.1	0.7	0.9	1.1	2.8	3.8	3.3	3.2	1.6	.5	18.7

1976 saw a large number of days (53) of multiple-storm situations (Tables 4-1 and 4-7). As early as May simultaneous storms were generated when Olga and Pamela tracked across the western Pacific causing extensive damage to the Philippines and to Guam. June through September saw six additional two-storm situations and one three-storm situation. The long duration of several storms (e.g., Olga, Pamela and Fran), accounted for the near average number of warnings issued despite the less than average number of tropical cyclones (Table 4-7). Although the season started quickly, the latter part of the season tapered off earlier than normal. For 36 days in September and October, normally a very active period, there were no warnings issued. Not since 1958, when 30 days passed without a depression, has such a lull in activity occurred during this time of the year. It is interesting to note that twin storms in the northern and southern hemisphere occurred during April when Tropical Storm Nancy formed in the Pacific north of the equator and TC 19-76 did likewise south of the equator.

Most of the damage during 1976 was associated with three of the four super typhoons. Damage estimates to public and private property for Pamela and Fran combined exceeded one billion dollars. Fran also accounted for 133 dead in Japan. While Pamela was responsible for 10 dead on Truk, the super typhoon miraculously caused only one fatality as it passed over Guam. Therese sank 12 ships, and left 1300 homeless due to heavy rains in Southern Japan. During May, Olga caused enhanced monsoonal rains over the Philippines which led to over 200 deaths and thousands homeless. In addition, Typhoon

Billie generated great waves which resulted in the drowning of 41 fishermen and swimmers as the storm passed through the Ryukyu Islands. It was subsequently responsible for 4 deaths in Taipei and caused millions of dollars of damage to facilities during its passage over northern Taiwan. Although Marie caused no known fatalities, it brought millions of dollars damage to crops and structures in the Palau Islands. In September Iris sank a Panamanian freighter and killed four as it tracked slowly across the South China Sea.

b. NORTH INDIAN OCEAN

During 1976 there were five tropical cyclones in the North Indian Ocean: three in the Bay of Bengal and two in the Arabian Sea. Table 4-5 presents the tropical cyclone distribution by month for 1976 and for the preceding five years. Except for the absence of activity during November, 1976 was climatologically normal. A total of 28 warnings were issued on the five cyclones, none of which exceeded 55 kt intensity. TC 25-76 occurred in the newly acquired JTWC area of responsibility, which this year was extended from 62E to the coast of Africa.

c. CENTRAL PACIFIC

The only Central Pacific tropical cyclone spawned during 1976 was in the month of September. A disturbance observed on the 20th ultimately developed into Hurricane Kate, and at one time became a threat to the Hawaiian Islands. It later recurved, passing northeast of Hawaii. Kate ended a 24 month absence of tropical cyclone activity in the Central Pacific, being the first hurricane since August 1974.

TABLE 4-4.

PACIFIC AREA TROPICAL CYCLONE FORMATION ALERT SUMMARY

YEAR	NUMBER OF ALERT SYSTEMS	ALERT SYSTEMS WHICH BECAME NUMBERED TROPICAL CYCLONES	TOTAL NUMBERED TROPICAL CYCLONES	DEVELOPMENT RATE
1972	41	29	32	71%
1973	26	22	23	85%
1974	35	30	36	86%
1975	34	25	25	74%
1976	34	25	25	74%

MONTHLY DISTRIBUTION

	J	F	M	A	M	J	J	A	S	O	N	D
FORMATION ALERTS	2	2	1	2	2	3	6	4	6	2	1	3

TABLE 4-5. FREQUENCY OF NORTH INDIAN OCEAN CYCLONES BY MONTH AND YEAR.

YEAR*	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1971	0	0	0	0	0	0	0	0	0	1	1	0	2
1972	0	0	0	1	0	0	0	0	2	0	1	0	4
1973	0	0	0	0	0	0	0	0	0	1	2	1	4
1974	0	0	0	0	0	0	0	0	0	0	1	0	1
1975	1	0	0	0	2	0	0	0	0	1	2	0	6
1976	0	0	0	1	0	1	0	0	1	1	0	1	5
AVG**	0.1	***	0.1	0.3	0.7	0.7	0.6	0.4	0.5	1.0	1.1	0.5	5.7

*1971-1974 REPRESENT BAY OF BENGAL CYCLONES ONLY

**1877-1960 AVERAGE (INCLUDING ARABIAN SEA) MARINERS WORLDWIDE CLIMATIC GUIDE TO TROPICAL STORMS AT SEA (H. L. CRUTCHER AND R. G. QUAYLE)

***LESS THAN 0.05 PER MONTH

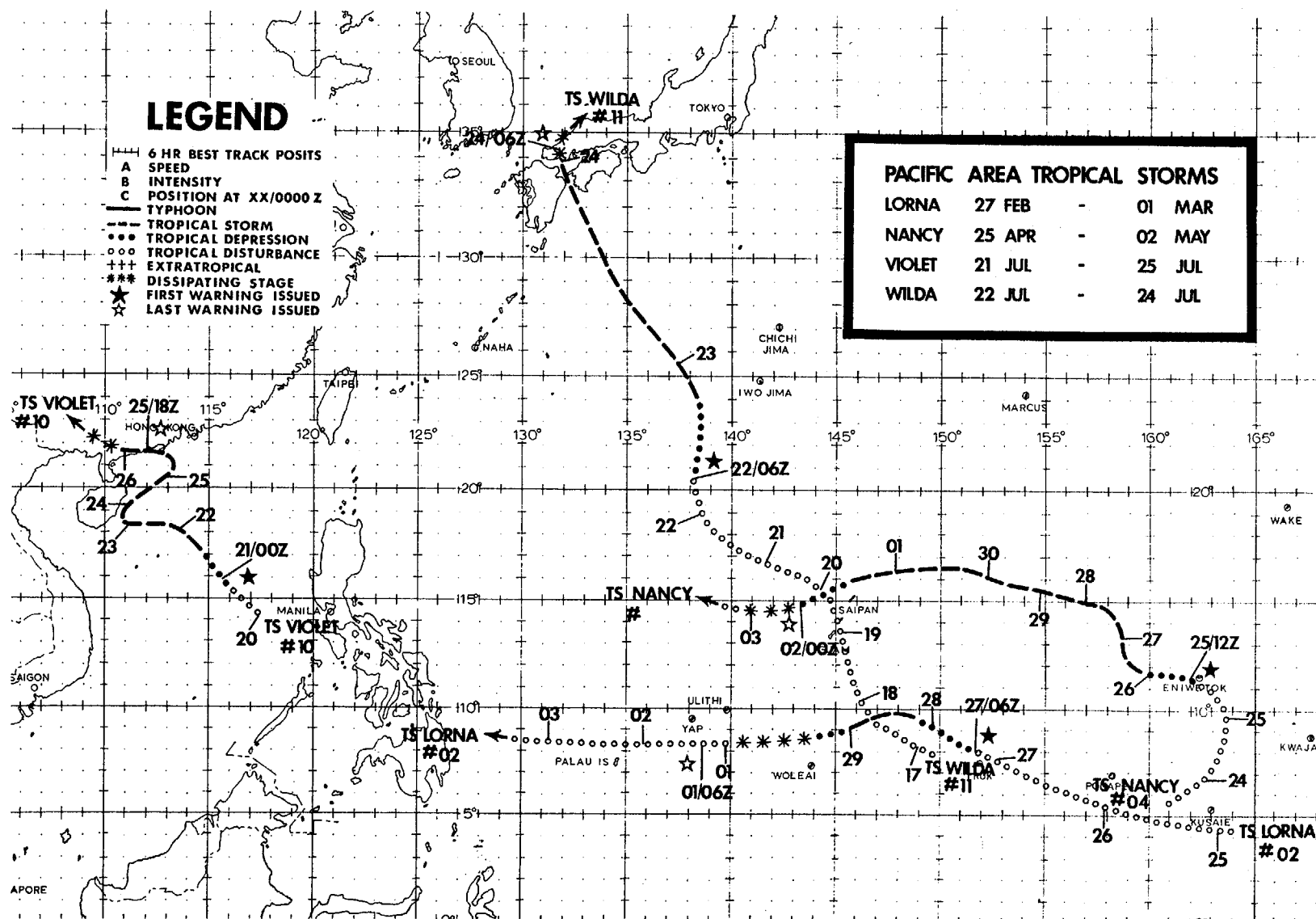
TABLE 4-6. FREQUENCY OF CENTRAL PACIFIC STORMS BY MONTH AND YEAR. (NUMBER IN PARENTHESIS INDICATE STORMS REACHING HURRICANE INTENSITY)

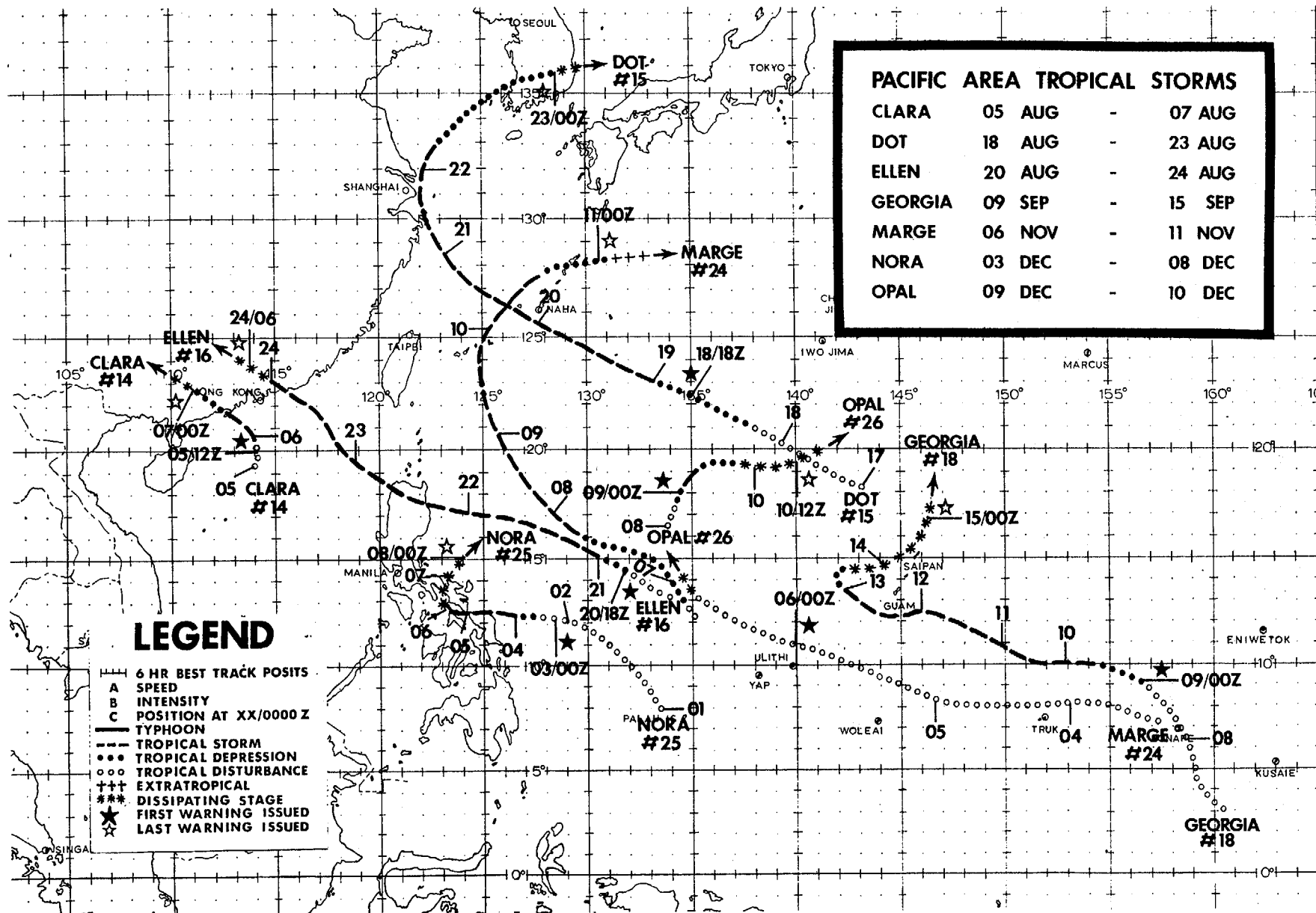
	JAN-JUN	JUL	AUG	SEP	OCT	NOV-DEC
1967	0	0	0	0	1	0
1968	0	0	2	0	0	0
1969	0	0	0	0	0	0
1970	0	0	1	0	0	0
1971	0	1 (1)	1	0	0	0
1972	0	0	3 (1)	1	0	0
1973	0	1 (1)	0	0	0	0
1974	0	0	2 (1)	0	0	0
1975	0	0	0	0	0	0
1976	0	0	0	1 (1)	0	0
AVERAGE	0	.2(.2)	.9(.3)	.2(.2)	.1	0

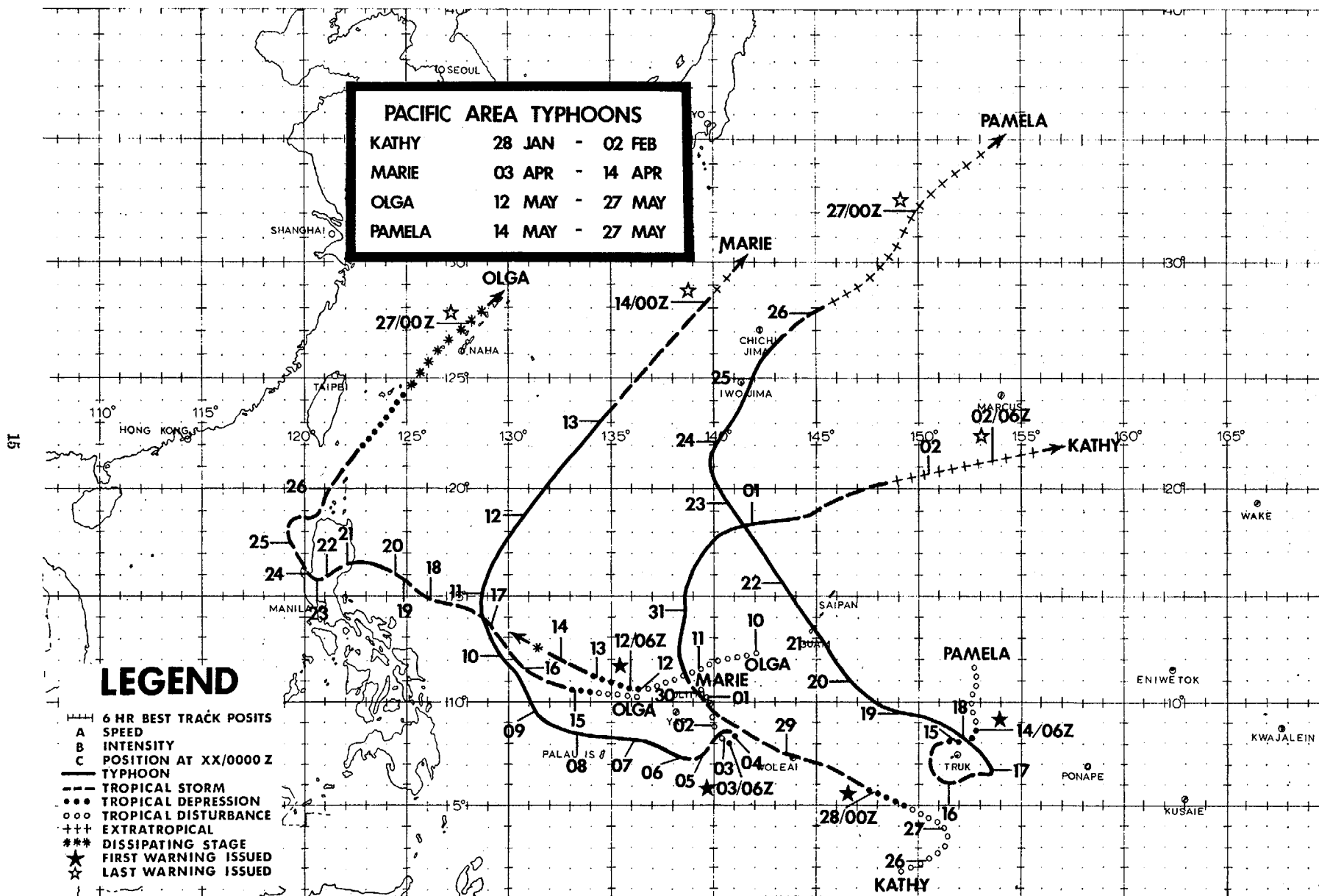
TABLE 4-7. SUMMARY OF JTWC WARNINGS 1959-1976.

	WESTERN NORTH PACIFIC		NORTH INDIAN OCEAN		CENTRAL NORTH PACIFIC	
	1976	AVERAGE 1959-75	1976	AVERAGE 1971-75*	1976	AVERAGE 1971-75
TOTAL NUMBER OF WARNINGS	661	680	28	25	42	33
CALENDAR DAYS OF WARNINGS	131	143	13	16	12	10
NUMBER OF WARNING DAYS WITH TWO CYCLONES	49	48	0	1	0	1
NUMBER OF WARNING DAYS WITH THREE OR MORE CYCLONES	4	9	0	0	0	0
TROPICAL DEPRESSIONS	0	5	-	-	0	1
TROPICAL STORMS	11	11	-	-	0	1
TYPHOONS/HURRICANES	14	19	-	-	1	1
I.O. TROPICAL CYCLONES	-	-	5	4	0	-
TOTAL TROPICAL CYCLONES	25	35	5	4	1	3

*BAY OF BENGAL ONLY 1971-1974

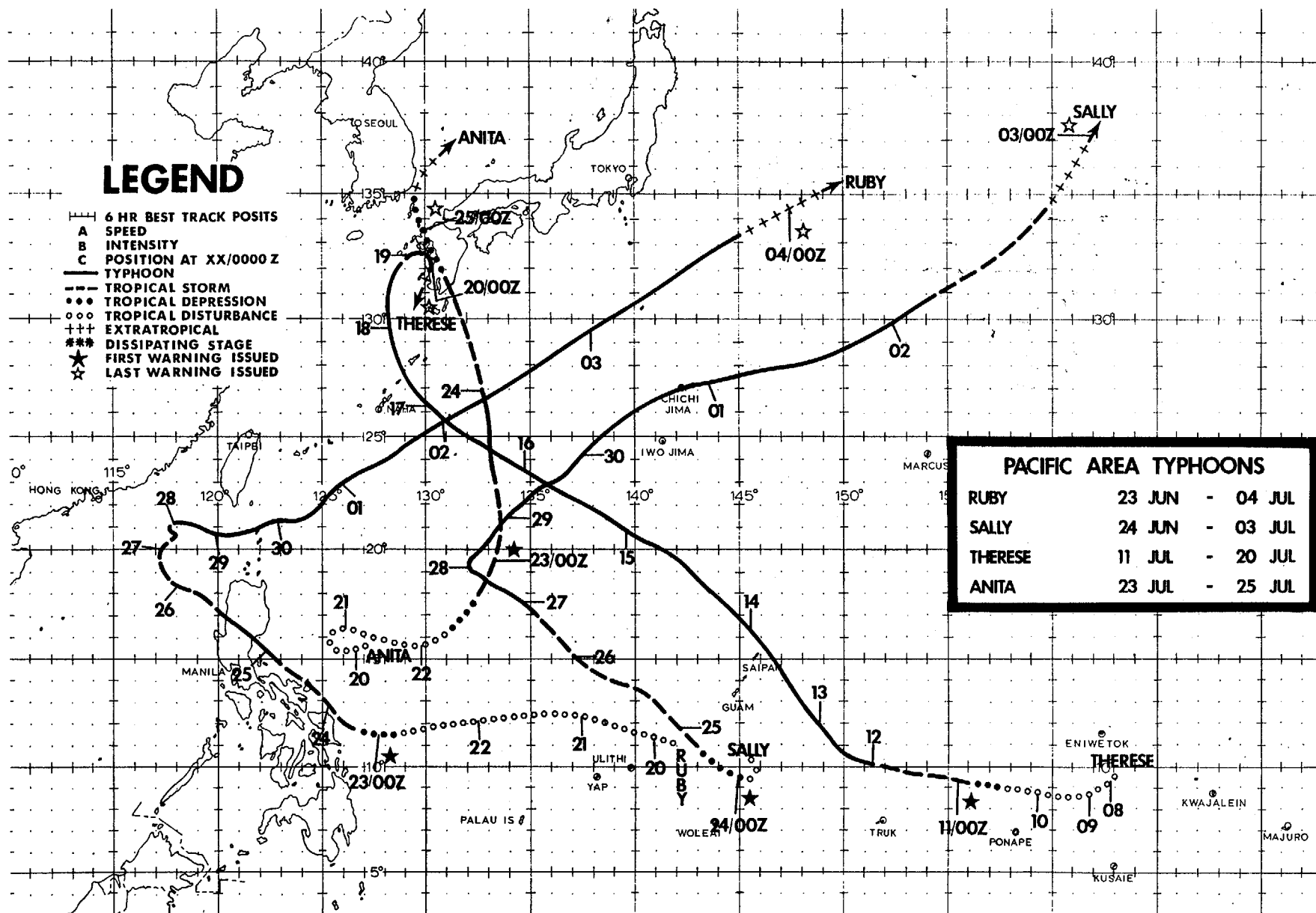






LEGEND

- 6 HR BEST TRACK POSITS
- A SPEED
- B INTENSITY
- C POSITION AT XX/0000 Z
- TYPHOON
- TROPICAL STORM
- ... TROPICAL DEPRESSION
- ooo TROPICAL DISTURBANCE
- +++ EXTRATROPICAL
- *** DISSIPATING STAGE
- ★ FIRST WARNING ISSUED
- ☆ LAST WARNING ISSUED

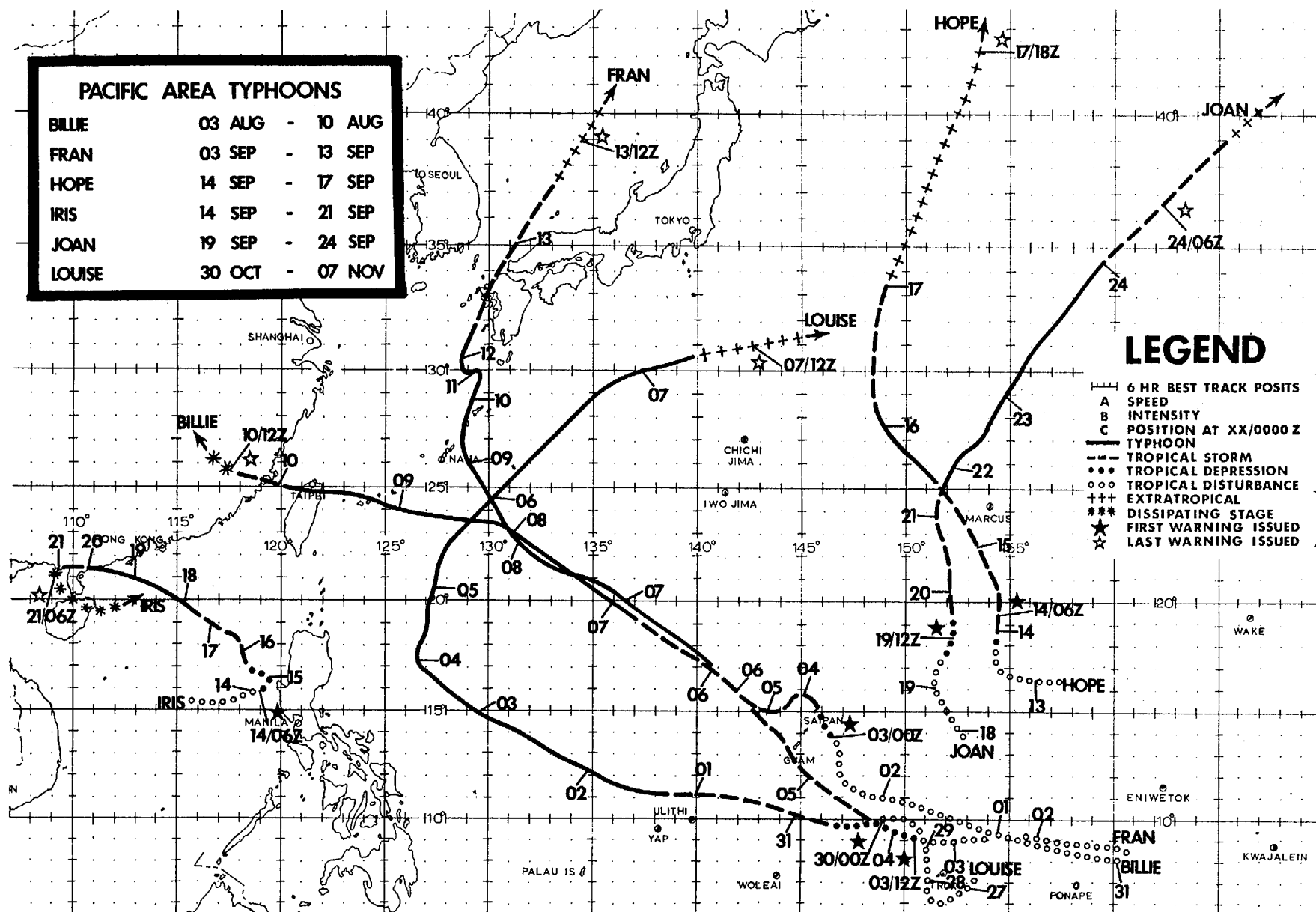


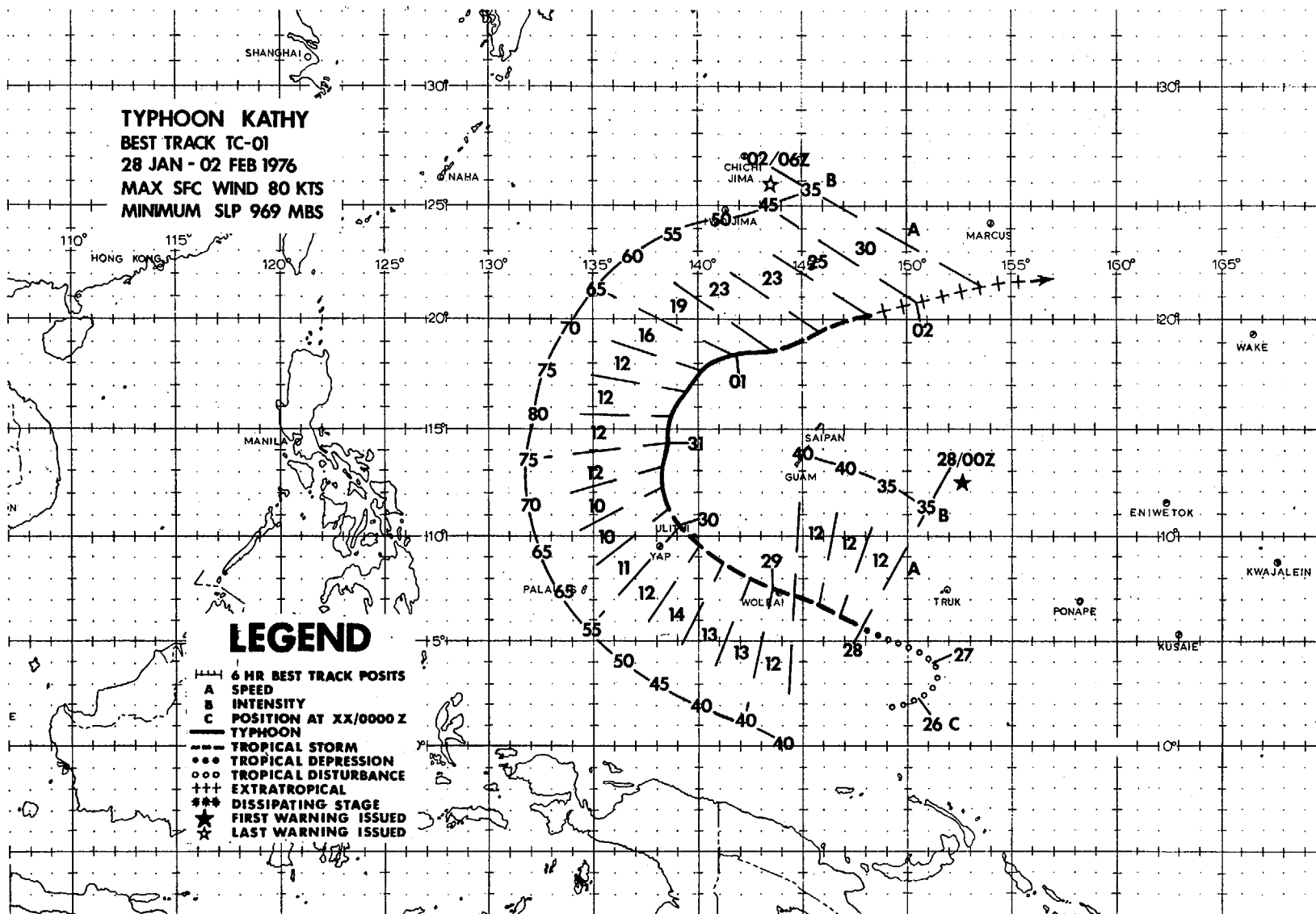
PACIFIC AREA TYPHOONS

BILLIE	03 AUG - 10 AUG
FRAN	03 SEP - 13 SEP
HOPE	14 SEP - 17 SEP
IRIS	14 SEP - 21 SEP
JOAN	19 SEP - 24 SEP
LOUISE	30 OCT - 07 NOV

LEGEND

- 6 HR BEST TRACK POSITS
- A SPEED
- B INTENSITY
- C POSITION AT XX/0000 Z
- TYPHOON
- TROPICAL STORM
- TROPICAL DEPRESSION
- TROPICAL DISTURBANCE
- EXTRATROPICAL
- DISSIPATING STAGE
- FIRST WARNING ISSUED
- LAST WARNING ISSUED





KATHY

The first typhoon of the 1976 season, a January storm, was initially detected by ship reports on the morning of the 25th as a cyclonic circulation unusually close to the equator (2N - 149E). By the morning of the 26th meteorological satellite data indicated a region of intense convective activity centered near 2.3N - 149.0E. During the next three days, the disturbance destined to become Typhoon Kathy slowly intensified as it moved northeastward and then northwestward (Fig. 4-1). On the morning of the 29th reconnaissance aircraft indicated that the circulation was nearly at tropical storm intensity, and the first warning was issued at 0000Z on the 28th. During the next 48 hours, Tropical Storm Kathy moved northwestward at 12 to 13 kt. Reconnaissance aircraft at 2143Z on the 29th reported the center of Kathy over Ulithi Atoll, and further indicated the absence of an eye or wall cloud. At 0000Z on the 30th, when Kathy was 40 nm to the northwest, Ulithi recorded winds of 25 kt and a sea level pressure of 1001.2 mb.

Later on the 30th a deep mid-latitude trough moved eastward into the Philippine Sea, weakening the mid-tropospheric subtropical ridge and providing an efficient outflow channel to the mid-latitude

westerlies. In response, Kathy intensified into a typhoon and moved northward, slowing to 10 kt. By that evening, the typhoon was drifting north through the weakness in the ridge, still intensifying slowly.

Late on the 30th, Kathy passed the point of recurvature and began to move north-northeastward as the slow moving mid-latitude trough to the west dug deeper toward the tropics (Fig. 4-2). Twelve hours later it attained its maximum intensity of 80 kt. At 0504Z on the 31st reconnaissance aircraft recorded maximum flight level winds of 90 kt and a minimum sea level pressure of 969 mb. At 0600Z a ship, JQFN, reported 55 kt winds 160 nm northeast of Kathy.

Embedded in westerly flow Kathy began to accelerate to the northeast. By the afternoon of February 1st the storm was on an east-northeast track moving at more than 20 kt, and had weakened into a tropical storm. The strong westerly shear and cooler temperatures rapidly stripped the storm of its tropical characteristics, and by 1800Z on the 1st Kathy had become extratropical. This extratropical low later produced copious precipitation over the Hawaiian Islands with Wailua, Oahu recording 18.81 inches of rain during the 6th, 7th and 8th of February.

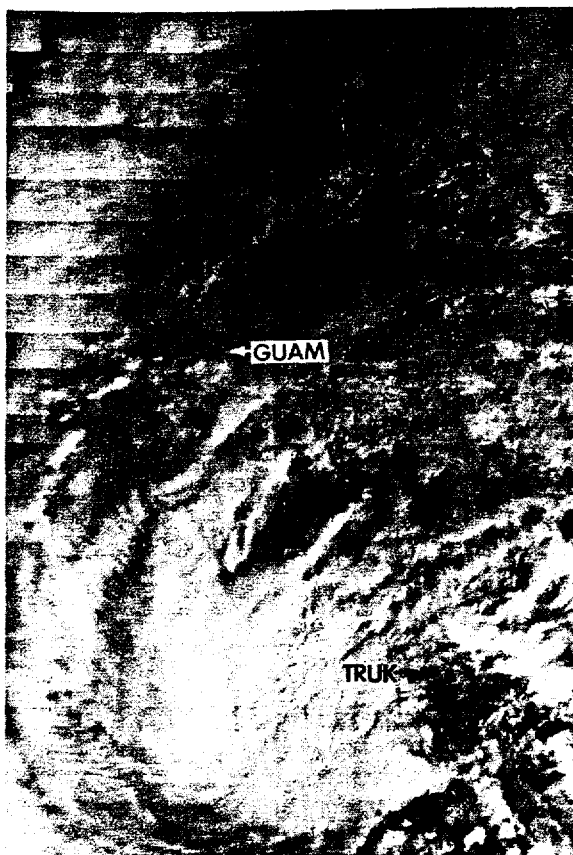


FIGURE 4-1. Kathy during early development 250 nm south of Truk, 26 January 1976, 2059Z. (DMSP imagery)

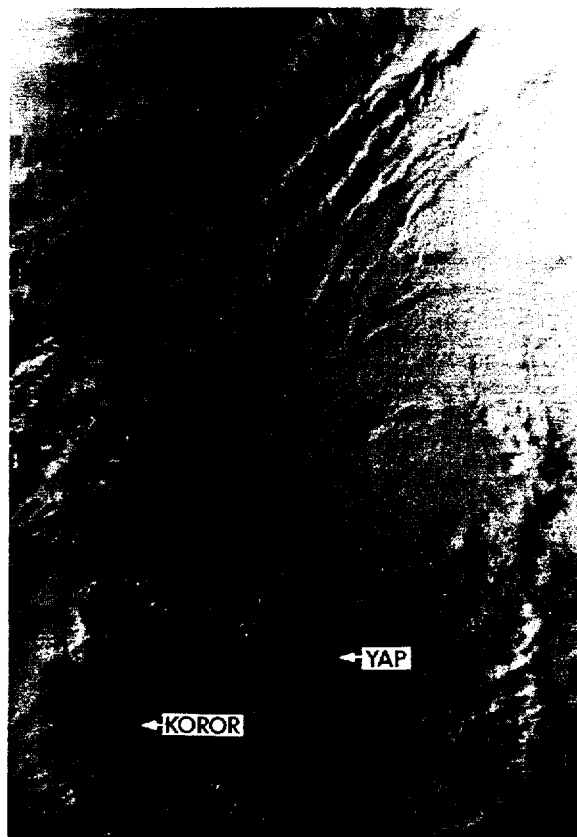


FIGURE 4-2. Typhoon Kathy just after recurvature and 8 hours prior to attaining its 80 kt peak intensity 260 nm north of Yap, 30 January 1976, 2152Z. (DMSP imagery)

MARIE

On the 1st of April a tropical disturbance was detected by satellite near 10N - 140E. Synoptic data revealed a weak surface cyclonic circulation with an associated upper level anticyclone. The system drifted slowly southward for the next 2 days. At 0030Z on the 3rd a formation alert was issued when synoptic data indicated the system had intensified to 25 kt, and increasing upper level outflow to the north promised good potential for further intensification. At 0600Z on the 3rd the first warning was issued. Six hours later the system was upgraded to Tropical Storm Marie when synoptic data confirmed aircraft reports of 35 kt winds.

Influenced by weak steering flow, the storm turned eastward in a counterclockwise loop, and during the evening of the 4th began taking a slow, southerly heading. Tropical Storm Marie intensified, and by 0600Z on the 5th had attained typhoon strength. Twelve hours later the typhoon had acquired a 6 kt movement toward the west-northwest, and for the next 48 hours maintained 65 kt winds.

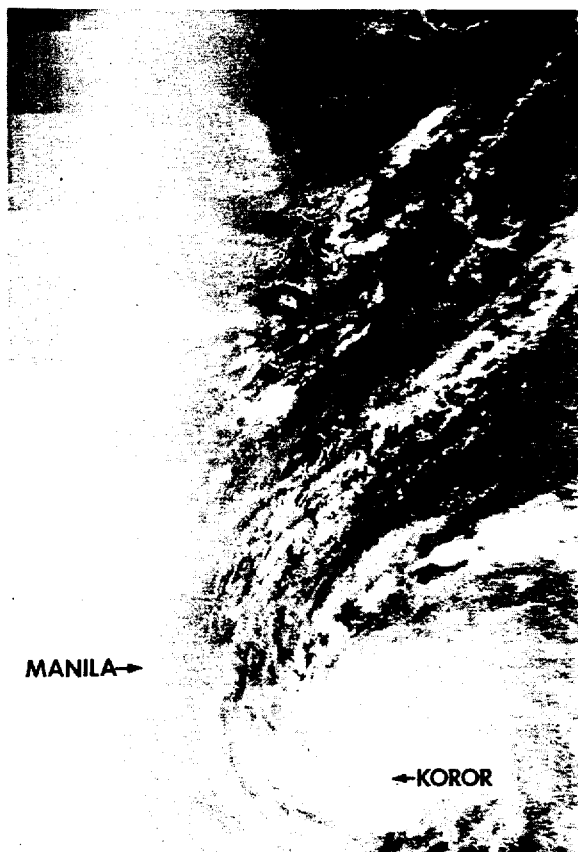


FIGURE 4-3. Moonlight image of Typhoon Marie near 70 kt intensity 70 nm north-northeast of Koror, Palau Islands, 7 April 1976, 1042Z. (DMSP imagery)

On the evening of the 7th, the typhoon once again began to intensify, as upper tropospheric winds over the Philippine Islands backed, indicating deeper troughing to the west and a more efficient link of the storm's outflow channel with the mid-latitude westerlies (Fig. 4-3). This intensification continued slowly during the subsequent 84 hours at a rate of about $\frac{1}{2}$ mb per hour.

At 1500Z on the 7th Typhoon Marie passed 40 nm north of Palau with peak gusts of 75 kt and a minimum sea level pressure of 993 mb recorded at Koror. While no deaths or injuries were reported, damage of more than \$4 million was incurred on the Palau Islands. Crop destruction was extensive as was damage to buildings and public utilities. As a result, Palau was declared a major disaster area.

By 0000Z on the 8th a weakness in the subtropical ridge appeared near the eastern coast of the Philippines. In response, Marie turned northward and recurved. During the typhoon's western-most position at 2100Z on the 10th, the system reached its maximum intensity of 115 kt (Fig. 4-4). The lowest sea-level pressure was 929 mb recorded by aircraft at 2031Z on the 10th. Typhoon Marie maintained 115 kt winds for 24 hours as its northeast movement increased to 11 kt. By 1800Z on the 11th Marie began to weaken while accelerating on a northeast track, closely following the 700 mb flow. Two days later the final warning was issued as Marie became extratropical.

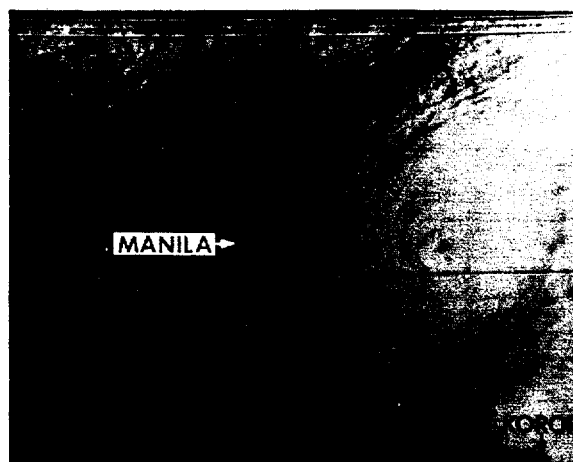
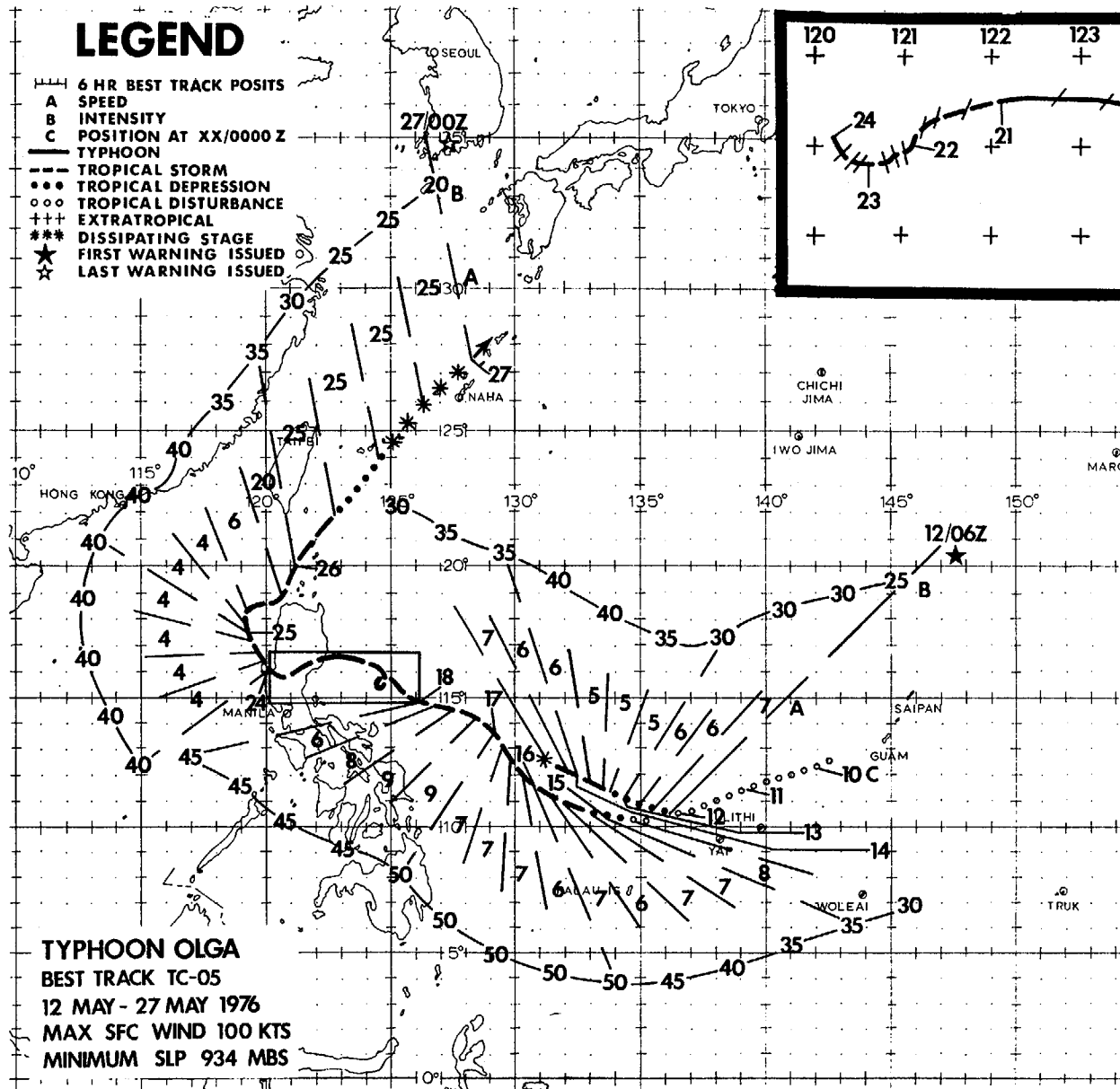


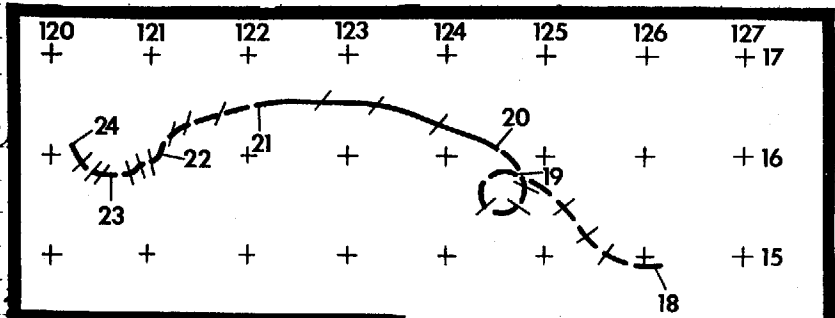
FIGURE 4-4. Typhoon Marie at point of recurvature with winds at peak intensity 450 nm east of Manila, 10 April 1976, 2251Z. (DMSP imagery)

LEGEND

- 6 HR BEST TRACK POSITS
- A SPEED
- B INTENSITY
- C POSITION AT XX/0000 Z
- TYPHOON
- TROPICAL STORM
- ... TROPICAL DEPRESSION
- ooo TROPICAL DISTURBANCE
- +++ EXTRATROPICAL
- *** DISSIPATING STAGE
- ★ FIRST WARNING ISSUED
- ☆ LAST WARNING ISSUED



TYPHOON OLGA
 BEST TRACK TC-05
 12 MAY - 27 MAY 1976
 MAX SFC WIND 100 KTS
 MINIMUM SLP 934 MBS



DTG	SPEED	INTENSITY
18/00Z		45
18/06Z	5	50
18/12Z	3	50
18/18Z	3	50
19/00Z	7	50
19/06Z	6	50
19/12Z	4	55
19/18Z	2	55
20/00Z	5	60
20/06Z	6	65
20/12Z	6	70
20/18Z	6	85
21/00Z	6	100
21/06Z	4	50
21/12Z	3	45
21/18Z	2	40
22/00Z	2	35
22/06Z	2	35
22/12Z	2	35
22/18Z	2	35
23/00Z	2	35
23/06Z	1	35
23/12Z	1	35
23/18Z	1	35
24/00Z	2	40
	4	

OLGA

Typhoon Olga originated within a very active trough near 10N and between 130 and 155E. As early as 4 May, several surface circulations were evident throughout this zone. By the 12th, a center analyzed near 10N - 140E showed indications that it would be the dominant circulation, and the first warning was issued at 0600Z on the 12th. From the onset, Olga was a unique system, having diffuse characteristics which it maintained throughout its life. One such trait was the lack of vertical stacking, observed when comparing satellite and aircraft positions. The low level circulation was often ill defined, and on several occasions multiple circulations could be identified.

Originally, Olga was tracked by satellite as a tropical disturbance moving toward the southwest, following the center of the upper level anticyclone. After 1200Z on the 12th a more climatological track toward the west-northwest was observed, but at half the speed normal for this time of year. This movement, along the southern edge of the subtropical ridge, persisted through the afternoon of the 13th when Olga was upgraded to a tropical storm. Later that night satellite data indicated the presence of a second circulation 120 nm to the east of the storm center. By the 14th the original center had dissipated and the convective energy had consolidated around this second center. The relocated system then proceeded toward the west-northwest while it slowly intensified, and attained tropical storm intensity for the second time. On the 16th Olga responded to a short wave trough in the westerlies and moved toward the north. However, on the 17th the storm resumed its west-northwest heading as the short wave progressed rapidly toward the east. It was at this point that satellite data indicated Olga was entering an unfavorable upper level shearing environment provided by a 200 mb ridge over Southeast Asia, which persisted

throughout the remainder of Olga's life.

On the 18th Olga began to slow its forward movement in response to a long wave trough moving off the east coast of China. At this point it was expected that the storm would recurve ahead of the trough, but instead, Olga began a counterclockwise loop, and slowly intensified despite the unfavorable upper level shear. On the 20th Olga completed its loop and attained typhoon intensity. After completing the loop the storm tracked toward the west at 6 kt, continuing to intensify. Between aircraft reports at 0330Z and 1947Z on the 20th, there was a drop in the central pressure of 44 mb (from 978 to 934 mb), a rate of 2.7 mb per hour (Fig. 4-5). With this rapid deepening, Olga made landfall on the east side of Luzon near 16.5N at approximately 0000Z on the 21st with winds estimated at 100 kt.

After landfall the small core of high winds subsided quickly (Fig. 4-6). For the next 24 hours Olga's center meandered toward the southwest along the east coast of Luzon passing near Bayler Bay with winds of 45 kt at storm center. Seeking the path of least resistance, Olga tracked through the Luzon lowlands during the next 48 hours exiting the island through Lingayen Gulf on the 24th. During its slow journey across Luzon, at 2 to 4 kt, Olga enhanced the southwest monsoon over southern Luzon, bringing rains in excess of 50 inches at Cubi Point and perhaps higher at other areas. The resulting floods contributed to over 200 deaths and thousands of homeless. For the next 24 hours Olga tracked toward the northwest through the Gulf reintensifying to 40 kt. On the 25th, the low level circulation separated from the hard core convection and tracked toward the northeast at an accelerated rate. Olga dissipated to the west of Okinawa on the 27th as it was absorbed into a subtropical disturbance west of the island.

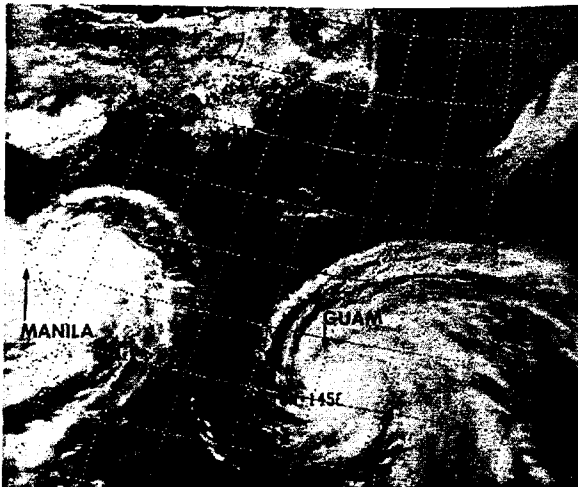


FIGURE 4-5. Typhoon Olga (left) at 70 kt intensity 85 nm east of Luzon begins rapid deepening as Typhoon Pamela moves toward Guam, 20 May 1976, 1109Z. (NOAA-4 imagery)

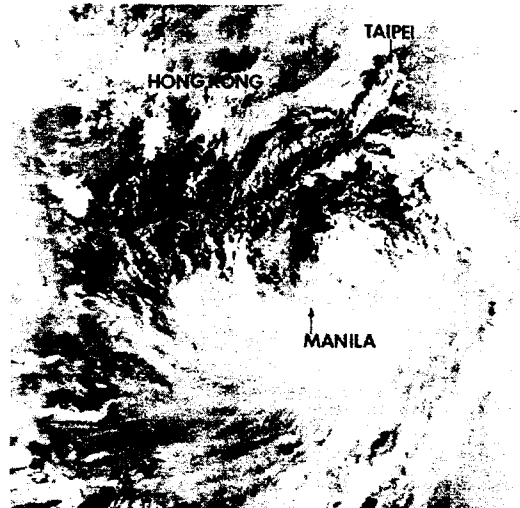
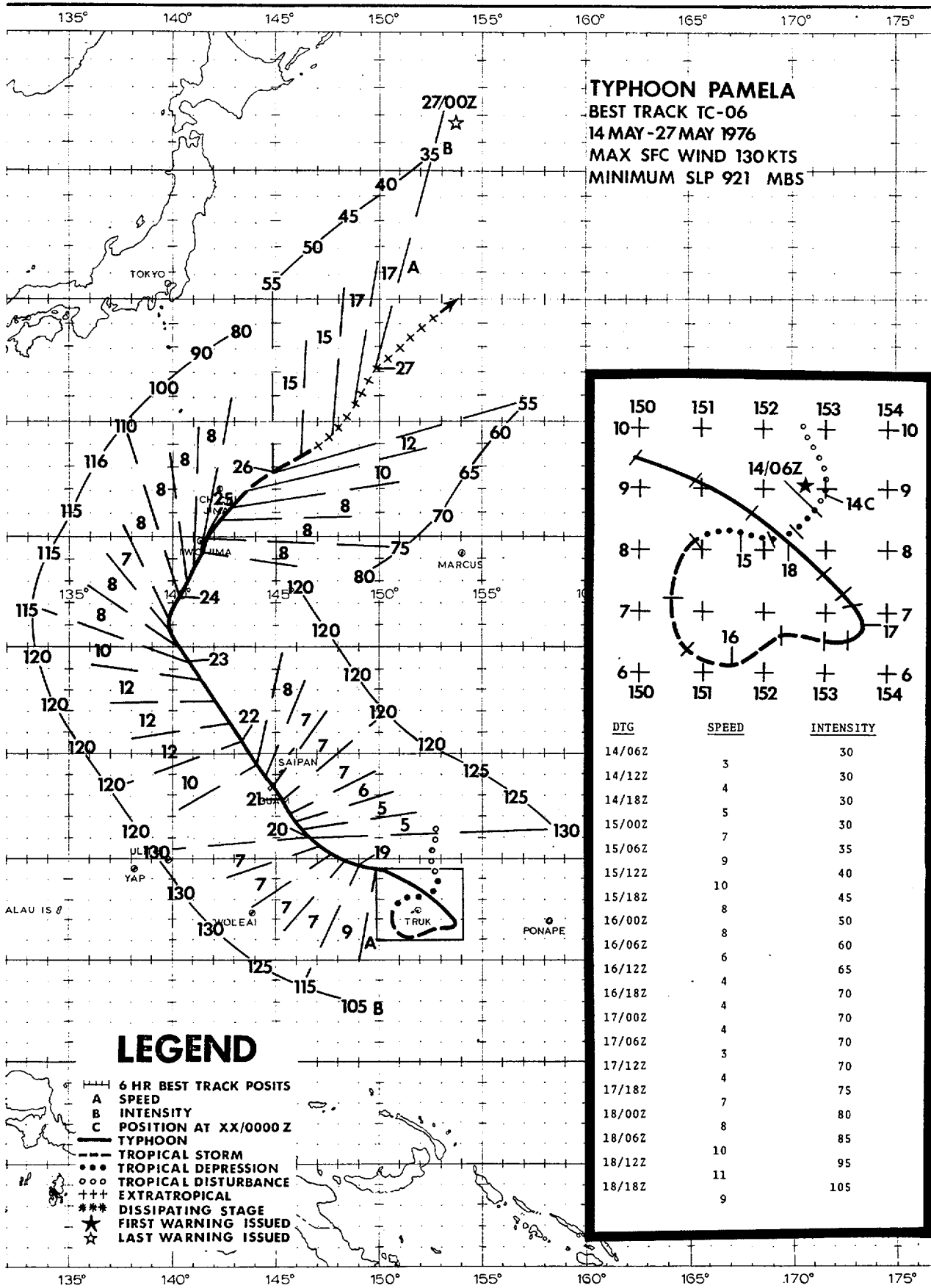


FIGURE 4-6. Olga at 40 kt intensity 95 nm north of Manila some 18 hours after moving inland over Luzon, 21 May 1976, 2304Z. (DMSP imagery)



PAMELA

Pamela, the fourth typhoon of 1976, was also the first super typhoon of the season. Destined to become one of the more destructive storms of history, Pamela was first detected on the morning of 13 May as a tropical disturbance near the eastern edge of the near equatorial trough approximately 230 nm north of Truk. For the next 24 hours the disturbance was difficult to track with the sparse synoptic data available, however, satellite pictures indicated a general southward movement. On the morning of the 14th the disturbance began to move to the southwest and at 0600Z it was upgraded to TD 06. By that evening the depression was moving west at 5 to 7 kt. At 0339Z on the 14th aircraft indicated surface winds near 40 kt and a sea level pressure of 998 mb; at 0600Z TD 06 was upgraded to Tropical Storm Pamela. Shortly thereafter Pamela began to move to the south at 9 to 10 kt, intensifying to 45 kt by 1800Z.

The next morning satellite data showed that Pamela was moving toward the south-southeast. Truk synoptic data at 1800Z indicated a sea level pressure of 998.6 mb, a 7.1 mb fall over the previous 24 hours. By 2200Z Truk had a surface pressure of 997.9 mb and northeasterly winds of 30 kt. At this time Pamela was forecast to trace a counter-clockwise loop around Truk. At 0348Z on the 16th an aircraft fixed Pamela 75 nm southeast of Truk and proceeded on a northeast track gathering peripheral information. Later that afternoon reports indicated destructive winds at Satawan Atoll (91338). The aircraft was diverted to the region of the atoll where the crew observed an extensive area of 55 to 65 kt flight level winds with surface winds estimated as high as 100 kt. At 0740Z on the 16th warning number 09 was amended to upgrade the storm to Typhoon Pamela. Pamela at this time was a small but intense typhoon (Fig. 4-7). The maximum winds were located on the south side of the 150 nm diameter central dense overcast.

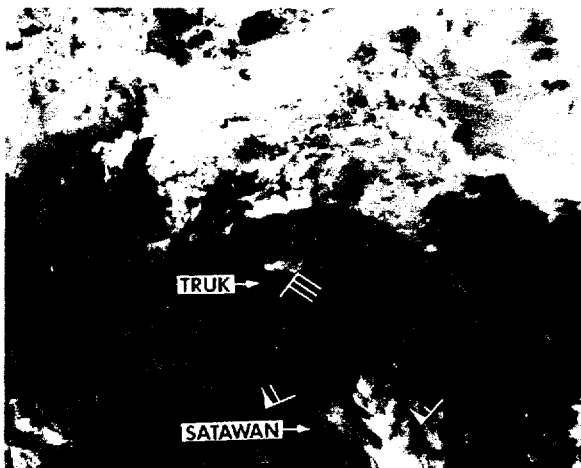


FIGURE 4-7. Infrared photograph of Pamela near 65 kt 75 nm southeast of Truk, 16 May 1976, 0938Z. Wind barbs represent 700 mb winds observed by reconnaissance aircraft from 0600Z to 1000Z. (DMSP imagery)

During the next 36 hours Pamela continued to intensify as it moved erratically at 3 to 6 kt, turning northward on the morning of the 17th. From the morning of the 16th until the morning of the 18th, Satawan Atoll continued to be buffeted with southwesterly and southerly surface winds of 50 to 55 kt. Damage was widespread on the tiny atoll, but no deaths were reported.

By the morning of the 18th Pamela had accelerated to 7 kt, passing within 50 nm of Truk. A minimum sea level pressure of 993.4 mb was recorded at 0400Z and a peak wind of 49 kt was observed an hour later. At 0327Z aircraft found maximum surface winds of 85 kt, a minimum pressure of 951 mb and a circular eye 10 nm in diameter. From the afternoon of the 17th to the afternoon of the 18th Truk recorded nearly 11 inches of rain which initiated mud slides killing 10 persons. Massive damage was inflicted on crops.

Pamela's erratic movements can be attributed to the influence of the Tropical Upper Tropospheric Trough (TUTT). On the 13th the TUTT began to establish itself north of the disturbance. Through the evening of the 15th the TUTT moved steadily south-southwestward, applying pressure to the upper anticyclone above Pamela. This pressure accounted for Pamela's southward and westward movement, and for the cyclone's slow intensification. By the morning of the 16th the TUTT had receded northward relieving the southward pressure, enhancing outflow and allowing the tropical storm to intensify. This release of pressure would have allowed the storm to move toward a climatological west-northwest track, however, by the 15th, an induced mid-tropospheric high pressure cell between Pamela and Typhoon Olga (in the Philippine Sea) had intensified, building eastward and forcing Pamela toward the east. By early morning on the 17th Olga had moved considerably to the west, the ridge had relaxed, and Pamela swung north and then northwest completing the loop around Truk.

From 0600Z on the 18th to 0600Z on the 19th Typhoon Pamela moved toward the northwest at an average speed of 9 kt, intensifying at a rate of 10 kt each 6 hours. At 1200Z on the 19th Pamela reached its super typhoon intensity of 130 kt with gusts to 160 kt (see photograph on front cover), which it maintained for 18 hours. At 2112Z on the 19th reconnaissance aircraft reported the minimum measured sea level pressure at 921 mb while observing concentric eye wall clouds with diameters of 10 and 20 nm. By the afternoon of the 20th, an eastward moving short-wave trough had created a weakness in the mid-tropospheric subtropical ridge north of Pamela. This, coupled with an elongated high pressure cell east of the typhoon, forced Pamela to acquire the north-northwestward track which would bring it over Guam.

A possible threat to the island had been identified as early as the 16th, and all forecasts subsequently issued indicated that Pamela was expected to pass within 100 nm of Guam. At 0450Z on the 18th the Commander, Naval Forces Marianas (COMNAVMAR) set Typhoon

Condition III for Guam. At 2330Z on the 18th COMNAVMAF set Typhoon Condition II and at 2330Z on the 19th Condition I was set.

During the next 24 hours northeasterly winds on Guam slowly intensified as Pamela approached the island. At 1800Z on the 20th the National Weather Service (NWS) at Taguac (91217) reported 73 kt winds at the 3000 ft level while surface winds were only 30 kt (Fig. 4-8). At 0315Z on the 21st reconnaissance aircraft from the 54th Weather Reconnaissance Squadron, Andersen AFB, Guam fixed the typhoon 30 nm southeast of the island. Less than 90 minutes later the northwestern edge of the eye was over the southeast coast of Guam.

The large, relatively calm eye, some 20 nm in diameter, required up to three hours to cross the center of the island (Fig. 4-9). Both Andersen AFB and the NWS at Taguac continually experienced winds exceeding 50 kt as the eye passed south of these stations. Most installations which had wind indicators lost their anemometers prior to the peak

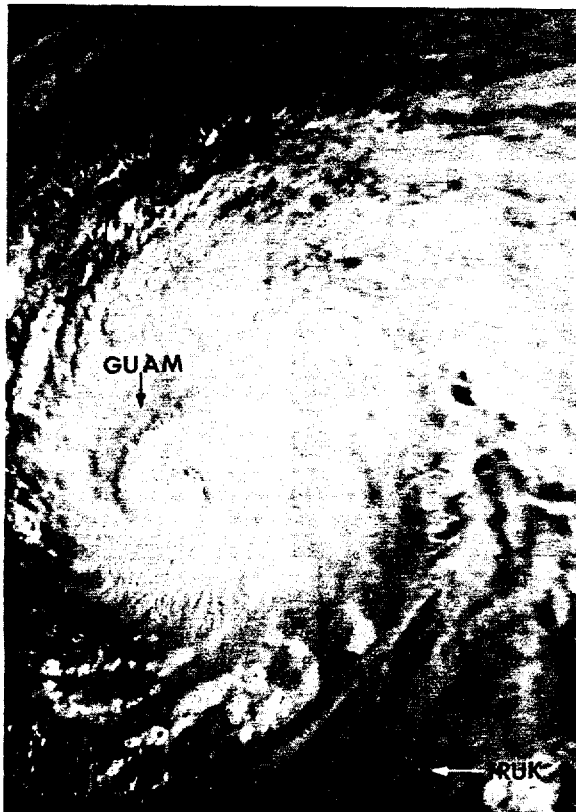


FIGURE 4-8. Typhoon Pamela at 120 kt intensity 65 nm southeast of Guam, 20 May 1976, 2134Z. (DMSP imagery)

winds. The maximum observed wind gust was 138 kt reported by the NWS Taguac at 0946Z. The minimum recorded surface pressure was 931.7 mb at NAS Brewer Field, some 5 nm northeast of the center. The lowest pres-

sure of approximately 930 mb (indicated by aircraft and land stations) supports estimated peak sustained winds of 120 kt with gusts of 145 kt. Pamela's winds gusted as much as 80 kt between peak and lull in a matter of minutes, resulting in extremely large pressure differences (60-70 lbs per square foot) on windward and leeward sides. Few unreinforced structures were able to withstand the intermittent pressure and wrenching effects. NWS Taguac recorded 33 inches of rain during Pamela's passage, with 27 inches falling in a 24-hour period.

SUPER TYPHOON PAMELA

GUAM, 21 MAY 1976

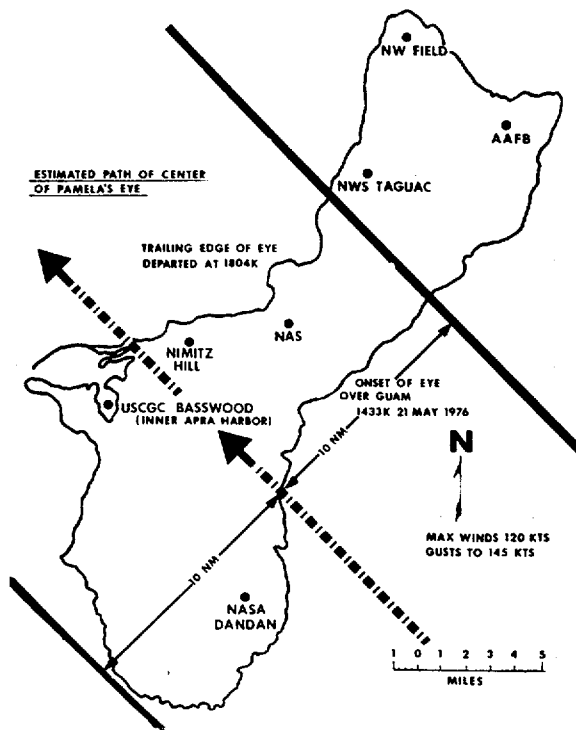


FIGURE 4-9. Estimated path of the center of Pamela's eye as it crossed Guam from 0433Z to 0804Z, 21 May 1976.

Although the winds of Pamela were 25 kt weaker than those of Typhoon Karen which flattened the island in November 1962, the slow 7 kt movement rendered Pamela more destructive (Fig. 4-10 and back cover). The 226 square mile island was buffeted by winds in excess of 100 kt for 6 hours, by winds of typhoon force for 18 hours and by winds exceeding 50 kt for 30 hours. The last warning on Pamela by JTWC was issued at 2320Z on the 20th. The alternate JTWC at Yokota AB, Japan assumed all warning responsibilities for Pamela and Olga during the next 5 days.

All Naval and Air Force units had been given adequate warning and had evacuated most

of their ships and aircraft. Despite extensive preparations damage to civilian and military facilities was severe, exceeding \$500 million (Fig. 4-11, Fig. 4-12 and Fig. 4-13). Ten small ships and tugs which had sought refuge in Apra Harbor, were either sunk or ran aground, and numerous other small craft were sunk or damaged (Fig. 4-14). One ship, the U. S. Coast Guard Cutter Basswood, courageously rode out the storm anchored in Apra Harbor where it recorded a peak gust of 120 kt and a minimum sea level pressure of 933.1 mb.

Miraculously, only one death occurred on Guam due to Pamela's passage. This low loss of life was attributed to the timely and accurate forecasts issued on the storm. A comprehensive account of lessons learned from Pamela is given in the Super Typhoon Pamela After-Action Report, prepared by CINCPAC REP GUAM/TTPI in August 1976.

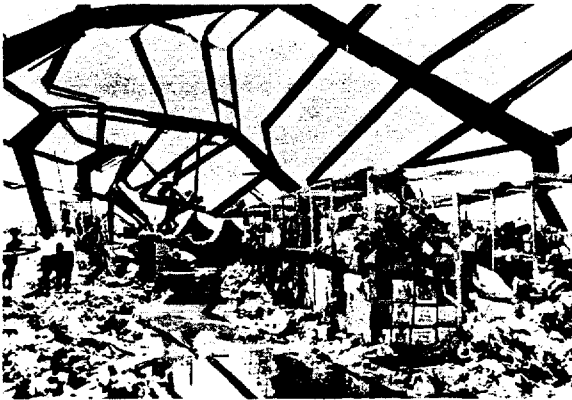


FIGURE 4-10. The twisted steel skeleton of a once substantial warehouse attests to the destructive force of Pamela. (Official U. S. Navy photograph)



FIGURE 4-12. The long line at Andersen AFB, Guam was representative of those throughout the island as the refugees of Pamela gathered for food, water and other supplies. (Official U. S. Navy photograph)



FIGURE 4-11. Destruction was widespread in Guam's civilian community. Concrete structures fared well, but wooden houses, power lines and the telephone system were all severely damaged. (Official U. S. Navy photograph)



FIGURE 4-13. Super Typhoon Pamela inflicted heavy damage to military facilities on Guam. This is Andersen AFB housing. (Official U. S. Navy photograph)



FIGURE 4-14. Two grounded tugs at U. S. Naval Station, Guam. Powerful wind and wave action produced by Typhoon Pamela affected even the inner Apra Harbor. (Official U. S. Navy photograph)

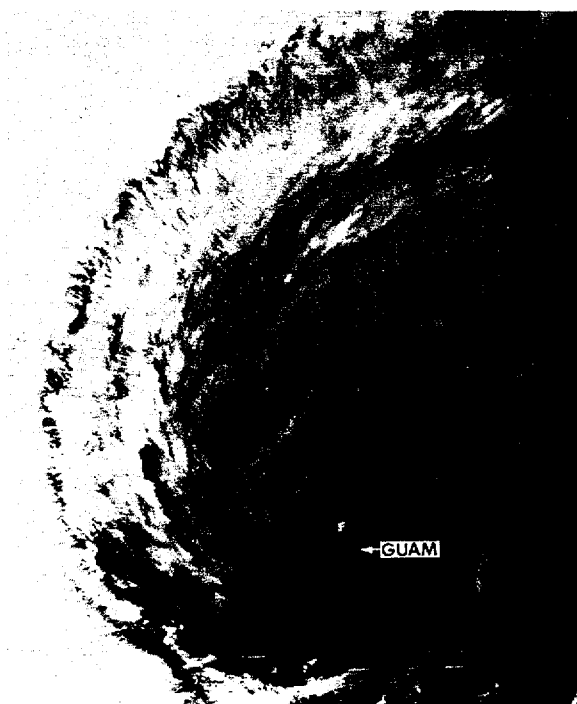


FIGURE 4-15. Infrared photograph of Typhoon Pamela at 120 kt 30 nm northwest of Guam, 21 May 1976, 1018Z. (DMSP Imagery)

After devastating Guam, Pamela continued to maintain its 120 kt intensity for an additional 36 hours, moving northwestward at an average speed of 10 kt (Fig. 4-15). Saipan (91232) experienced gusts of 55 kt and received 10 inches of rain as the storm passed 120 nm west of the island. As Pamela continued to threaten the northern Mariana Islands, mop-up operations were in full swing on Guam (Fig. 4-16 and Fig. 4-17). Although the civilian and military factions were well-organized and worked closely together, recovery efforts took months.

On the morning of the 23rd Pamela, still packing winds of 115 kt, slowed to 8 kt, and by that evening had passed through a weakness in the mid-tropospheric subtropical ridge, recurving to the northeast. At 2000Z on the 24th, Pamela passed 15 nm to the east of Iwo Jima (47981) blanketing the island with 75 kt winds (Fig. 4-18). By 1800Z on the 25th the system had weakened into a tropical storm. The cooler sea surface temperatures and tremendous vertical shear rapidly stripped the storm of its tropical characteristics, and by the afternoon of the 26th Pamela had become extratropical.

Pamela's 15 day trek took it a distance of 2570 nm during which a total of 52 warnings were issued, 40 of them as a typhoon.

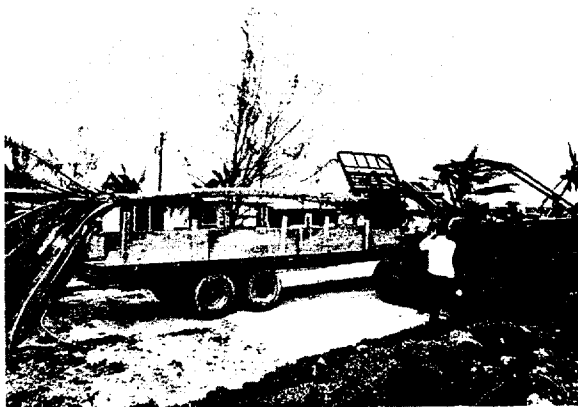


FIGURE 4-16. An Air Force crew removes one of numerous trees uprooted during Pamela's rampage. This was typical of island-wide clean-up operations performed by military and civilian personnel. (Official U. S. Navy photograph)

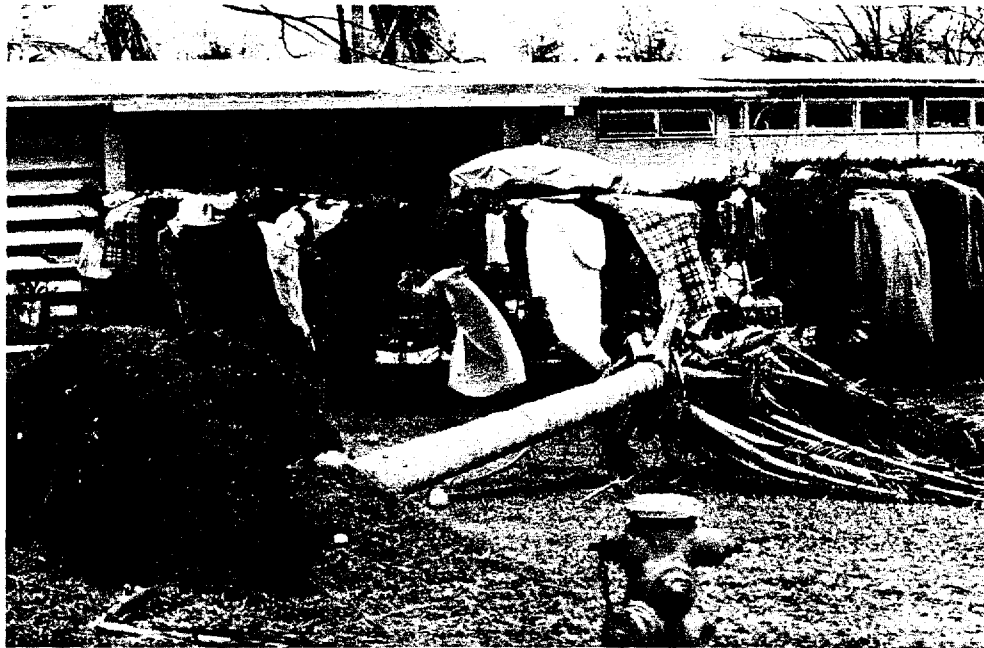


FIGURE 4-17. Few, if any, establishments on Guam escaped water damage from Pamela's driving rains. Massive destruction to power transmission facilities rendered drying-out a slow process. (Official U. S. Navy photograph)

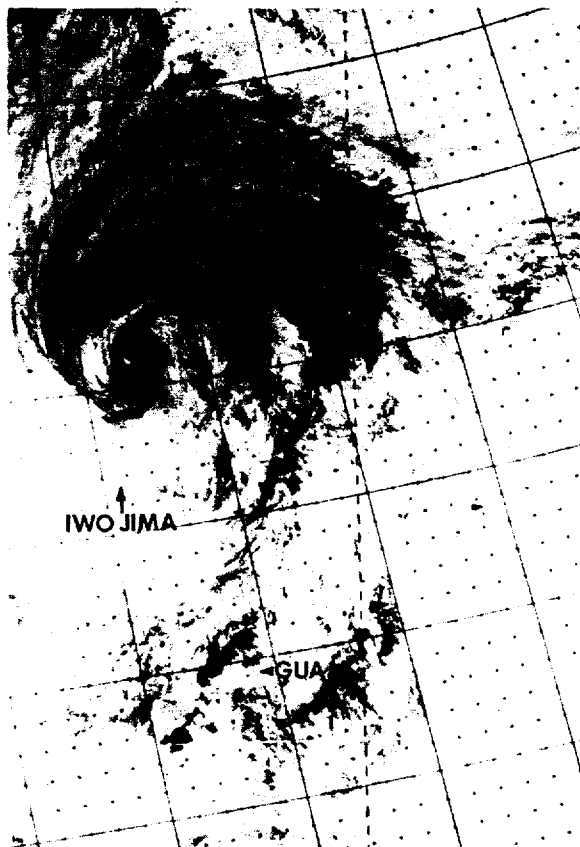


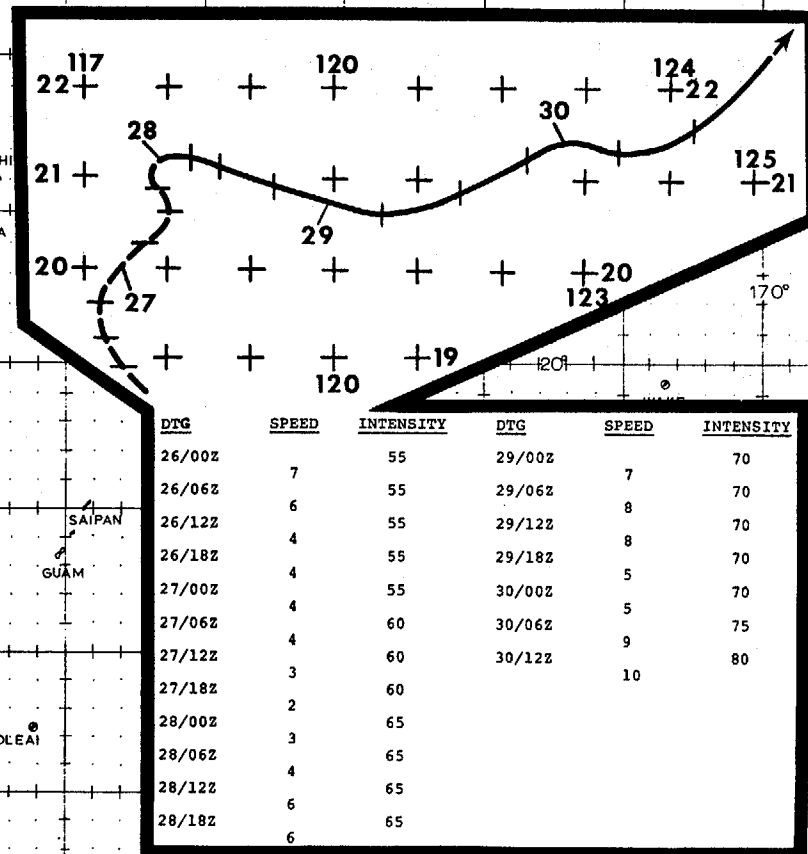
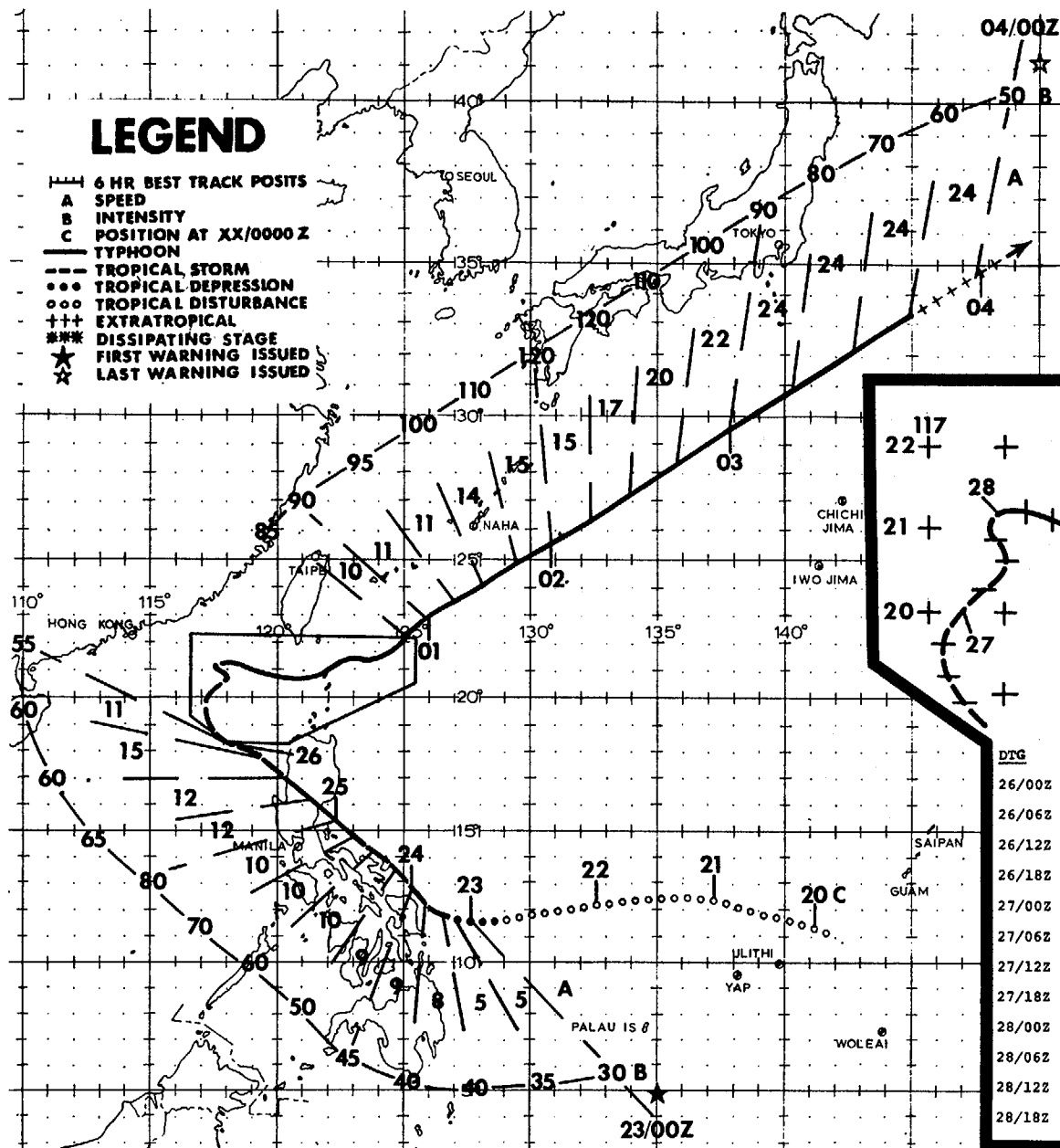
FIGURE 4-18. Infrared image of Typhoon Pamela at 65 kt 95 nm northeast of Iwo Jima, 25 May 1976, 0931Z. (DMSP imagery)

LEGEND

- 6 HR BEST TRACK POSITS
- A SPEED
- B INTENSITY
- C POSITION AT XX/0000 Z
- TYPHOON
- TROPICAL STORM
- TROPICAL DEPRESSION
- TROPICAL DISTURBANCE
- EXTRATROPICAL
- *** DISSIPATING STAGE
- ★ FIRST WARNING ISSUED
- ★ LAST WARNING ISSUED

TYPHOON RUBY
BEST TRACK TC- 07
23 JUN - 04 JUL 1976
MAX SFC WIND 120 KTS
MINIMUM SLP 934 MBS

30



RUBY

The month of June was characterized by a persistent monsoon trough which was the breeding ground for numerous tropical disturbances. Ruby, the 5th typhoon of the season, was detected in this trough as an area of heavy thunderstorm activity located some 250 nm southwest of Guam. This region of convective activity was monitored for 3 days before undergoing significant intensification.

On the morning of the 23rd satellite data indicated that the disturbance had organized into a tropical depression located some 450 nm southeast of Manila, moving westward. Based on this information the first warning was issued on the 23rd at 0000Z. Reconnaissance aircraft at 1205Z indicated that TD 07 had attained tropical storm intensity; flight level winds of 70 kt and a central pressure of 987 mb were reported. Radar reports from Catanduanes Island (98446) further indicated that Tropical Storm Ruby was moving northwestward in response to weak steering south of the mid-tropospheric subtropical ridge.

At 2100Z on 23rd reconnaissance aircraft reported further development; Ruby had intensified, with an eye and surface winds in excess of 70 kt. This rapid intensification was in response to the westward movement of an intense cold-core low in the Tropical Upper Tropospheric Trough (TUTT) which increased the upper level outflow and destabilized the tropospheric column, enhancing convection.

On the afternoon of the 25th Ruby, still tracking northwestward, began its passage over central Luzon crossing the eastern coast 10 nm south of Cape Ildefonso with winds of 80 kt. Official reports of damage resulting from Ruby's passage were unavailable. However, Pacific Stars and Stripes did report in their July 4th issue that 16 persons in the province of Benguet were killed as a result of mudslides triggered by heavy rains.

Passage over the Philippines weakened Ruby into a tropical storm. Further weakening was experienced in the South China Sea when the storm's vertical organization became sheared by strong upper tropospheric north-easterly flow emanating from the massive Asian upper level anticyclone.

On the morning of the 26th, Ruby began to move northward, and passed 35 nm east of Pratas Island on the 27th at 0600Z. Thirty-five knot winds and a sea level pressure of 985 mb were observed. By the morning of the 28th satellite data indicated that the vertical organization had become realigned and that Ruby had reintensified (Fig. 4-19). This had resulted from the westward regression of an upper tropospheric short wave trough to a position slightly northwest of Ruby's anticyclone. This blocked the earlier upper level shearing flow and enhanced outflow. Shortly after realignment a slow, eastward progression of the upper tropospheric trough steered Ruby to the east toward Typhoon Sally. It appears that any Fujiwara interaction between Ruby and Sally was either

very small or nonexistent.

As Ruby traveled eastward through the Bashi Channel, radar reports from Kao-hsiung indicated eastward movement and intensification (Fig. 4-20). Reconnaissance aircraft at 1600Z on July 1st recorded the lowest pressure, 934 mb, and indicated that Typhoon Ruby was moving toward the northeast.

Ruby maintained typhoon intensity until the night of the 3rd when it again moved into a hostile shearing environment. Meteorological satellite data at 2312Z on the 3rd indicated that Ruby had finally become extratropical after its 10 day trek.

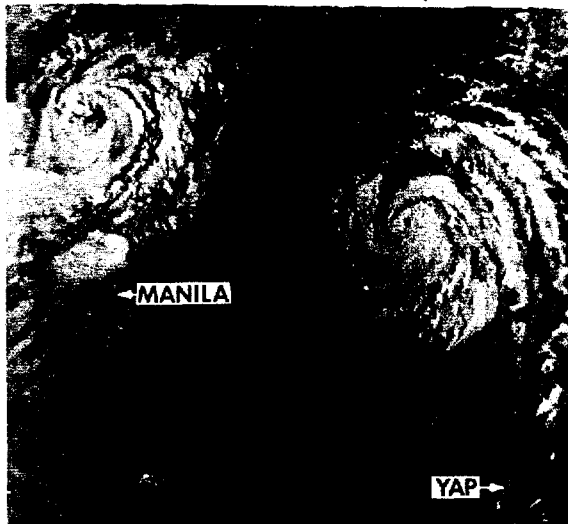


FIGURE 4-19. Ruby (left) near typhoon intensity 430 nm north-northwest of Manila, 27 June 1976, 2223Z. Typhoon Sally is some 800 nm to the east-southeast. (DMSP imagery)

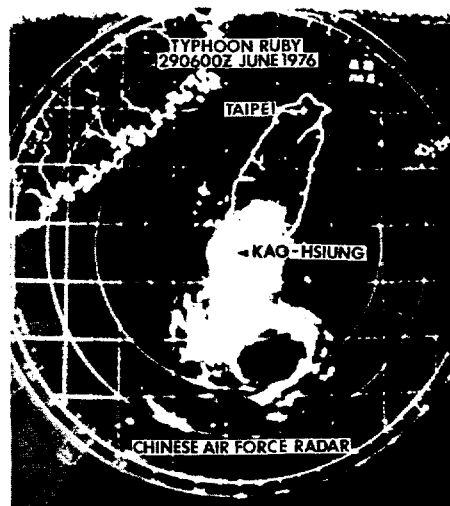
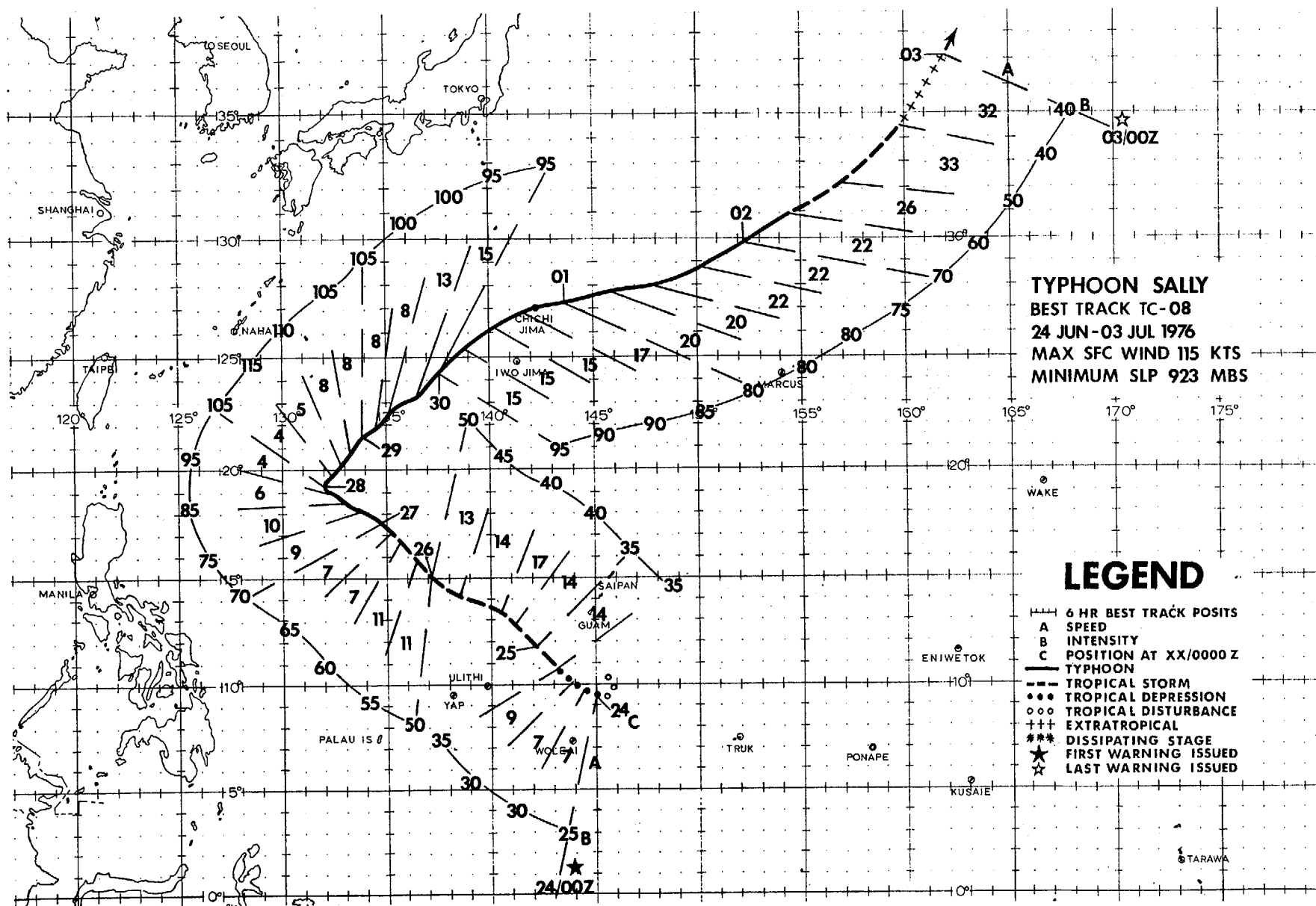


FIGURE 4-20. Radar presentation of Typhoon Ruby at 70 kt intensity 125 nm south-southeast of Kao-hsiung, Taiwan, 29 June 1976, 0600Z. (Picture courtesy of Central Weather Bureau, Taipei, Taiwan, Republic of China.)



SALLY

Sally, the 6th typhoon of the season, was first detected on the evening of June 23rd as a weak disturbance in the near-equatorial trough 210 nm south of Guam. During the next 36 hours the disturbance remained quasi-stationary as it slowly intensified. The first warning was issued at 0000Z on the 24th as the system intensified to 30 kt and began moving northward at 7 kt. Intensification was slow during the subsequent 30 hours as southeastward pressure from the Tropical Upper Tropospheric Trough (TUTT) to the northwest inhibited establishment of an efficient outflow channel to the north. By the evening of the 26th the TUTT had moved northward and Sally began more rapid intensification, attaining typhoon intensity at 1800Z on the 26th and a maximum intensity of 115 kt 36 hours later (Fig. 4-21 and Fig. 4-19: Typhoon Ruby). Reconnaissance aircraft reported a 40 mb drop in pressure (964 to 924 mb) from 0716Z on the 27th to 0230Z on the 28th, an average fall of 2 mb per hour.

By 1200Z on the 27th, Sally had slowed to 6 kt and had taken a more northward track. During the following 12 hours the typhoon moved slowly north, then north-northeast as Ruby, some 820 nm to the west, attained

typhoon force and began moving toward the east. By 1200Z on the 29th the distance between the two typhoons had closed to 790 nm and conditions for a Fujiwara interaction appeared favorable. However, between 1200Z on the 28th and 0000Z on the 29th, the axis of the mid-tropospheric subtropical ridge shifted some 300 nm to the south as westerly winds rapidly expanded equatorward. This unusually rapid shift of westerlies allowed a mid-tropospheric trough which had been far north of Sally to also move equatorward. Sally responded by recurving to the northeast and by 1200Z on the 29th had accelerated to 13 kt. At 0000Z on the 30th a ship, EWWY, reported sustained 50 kt winds 120 nm northwest of the storm which still possessed 95 kt winds (Fig. 4-22).

At 1800Z on the 30th, Chichi Jima (40 nm northeast of Sally) reported southeasterly winds of 30 kt and a sea level pressure of 980.5 mb. Twelve hours later the rapidly moving storm was 180 nm east-northeast of the island. During the 2nd of July the system began more rapid weakening and became extratropical on the 3rd while traveling at more than 30 kt and still possessing surface winds of 40 kt.

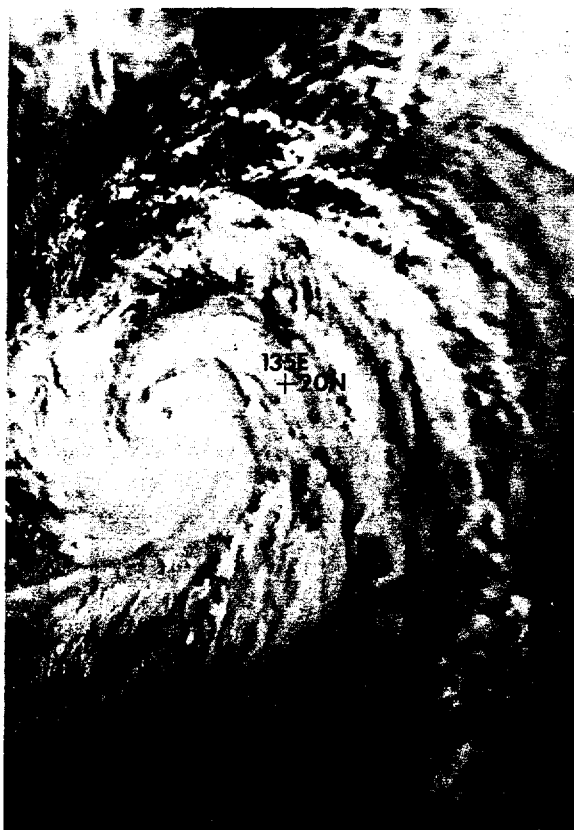


FIGURE 4-21. Typhoon Sally at point of recurvature with 100 kt intensity 540 nm southeast of Okinawa, 27 June 1976, 2223Z. (DMSP imagery)

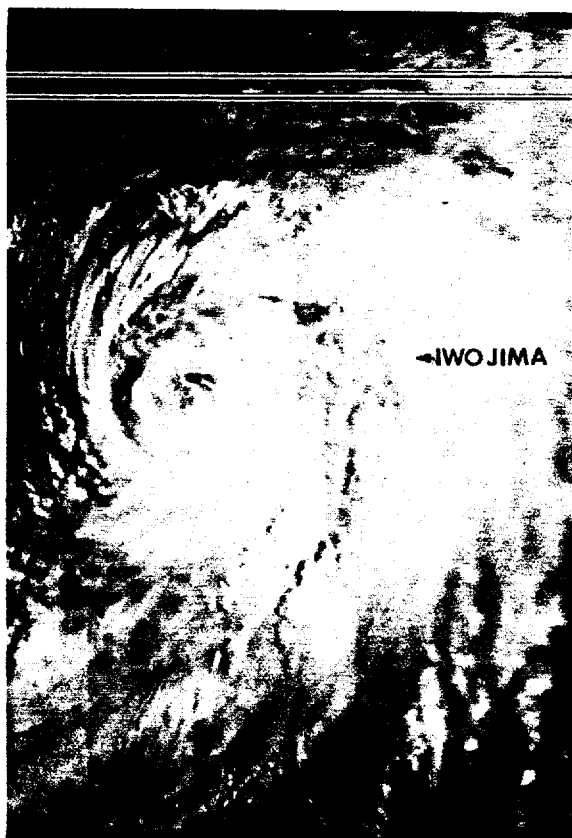
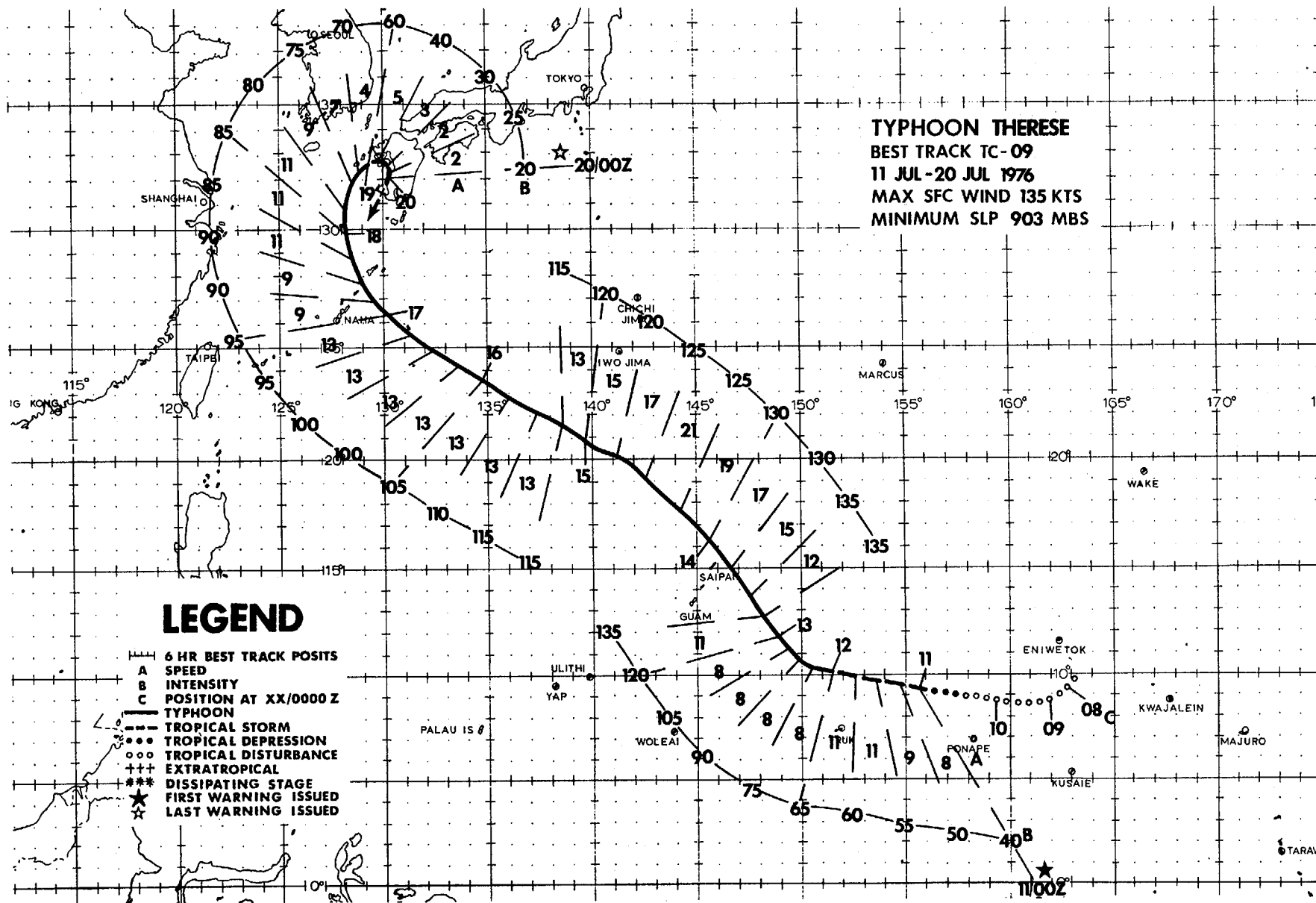


FIGURE 4-22. Typhoon Sally at 95 kt 235 nm west-southwest of Iwo Jima, 29 June 1976, 2159Z. (DMSP imagery)



THERESE

Near the end of the first week in July a tropical disturbance was detected by satellite near 9N-160E, moving slowly westward. At 2322Z on the 9th a formation alert was issued when satellite data indicated that the system was beginning to organize. During the next 24 hours the disturbance intensified rapidly, and aircraft observed winds of tropical storm intensity. At 0000Z on the 11th the first warning was issued on Tropical Storm Therese with winds of 40 kt near the center. For the next 24 hours Therese continued to intensify while accelerating slowly on a west-northwest course south of a well established subtropical ridge. By 0000Z on the 12th Therese had reached typhoon intensity. As the subtropical ridge to the north of the storm shifted northward, the typhoon reacted by slowing and moving toward the northwest. Near 1200Z on the 12th explosive deepening began to occur in response to enhanced outflow resulting from a cold-core, upper tropospheric low northwest of Therese. Reconnaissance aircraft indicated that from 0805Z on the 12th until 0537Z on the 13th, the storm's central pressure plummeted 66 mb, a rate of 3.1 mb per hour (Fig. 4-23). Therese had become the 2nd super typhoon of the season, attaining a minimum surface pressure of 903 mb and maximum winds of 135 kt at 0600Z on the 13th. Therese maintained super typhoon intensity for the next 18 hours, and at 2100Z on the 13th passed 30 nm northeast of Saipan with 130 kt winds near the center. Saipan sustained only minor damage with observed winds estimated at 75 to 100 kt.

Typhoon Therese began to accelerate along the southwestern periphery of the subtropical ridge heading toward a weakness near 130E. The system continued to weaken

slowly as it tracked farther north, still maintaining good outflow in all quadrants. At 1800Z on the 16th Therese passed 25 nm southwest of Minamidaito Jima where maximum sustained winds of 50 kt and a minimum sea level pressure of 966.9 mb were recorded. By the morning of the 17th Therese had slowed to 9 kt, and began to recurve toward the north in response to a long wave trough at the 200 mb level. At 0900Z the typhoon, still possessing 90 kt winds, passed 60 nm northeast of Okinawa where 41 kt gusts were recorded at Kadena AB. Directly ahead of the storm, Tokuno-Shima was reporting 50 kt winds. At 1200Z the island experienced eye passage with a recorded central pressure of 958 mb (Fig. 4-24).

For the next 24 hours Therese continued moving northward along the western edge of the subtropical ridge maintaining typhoon intensity. At 1200Z on the 18th Meshima (47842) reported sustained winds of 65 kt and minimum sea level pressure of 971.2 mb. Shortly thereafter Therese passed 10 nm east of the island as it turned to the northeast toward the west coast of Kyushu. By 1200Z on the 19th Therese had made landfall on the coast of Kyushu with 40 kt winds. After crossing the coast, the storm continued to dissipate over the mountainous terrain. The final warning was issued at 0000Z on the 20th as Therese became quasi-stationary over southern Japan.

Prior to dissipation, Therese brought nearly 20 inches of rain to the island of Kyushu. The storm flooded more than 1000 homes and sank 12 ships. During the onslaught, 3 persons were killed, more than 1300 were rendered homeless, and damage to crops was estimated in the millions of dollars.

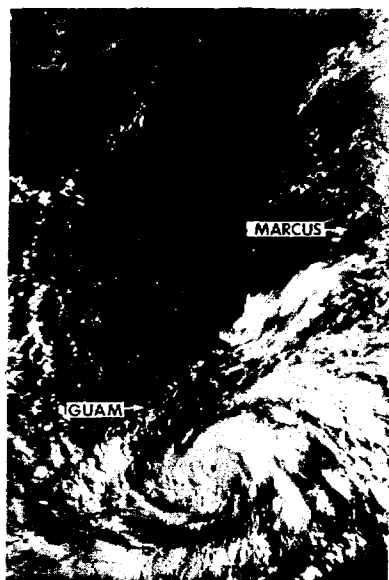
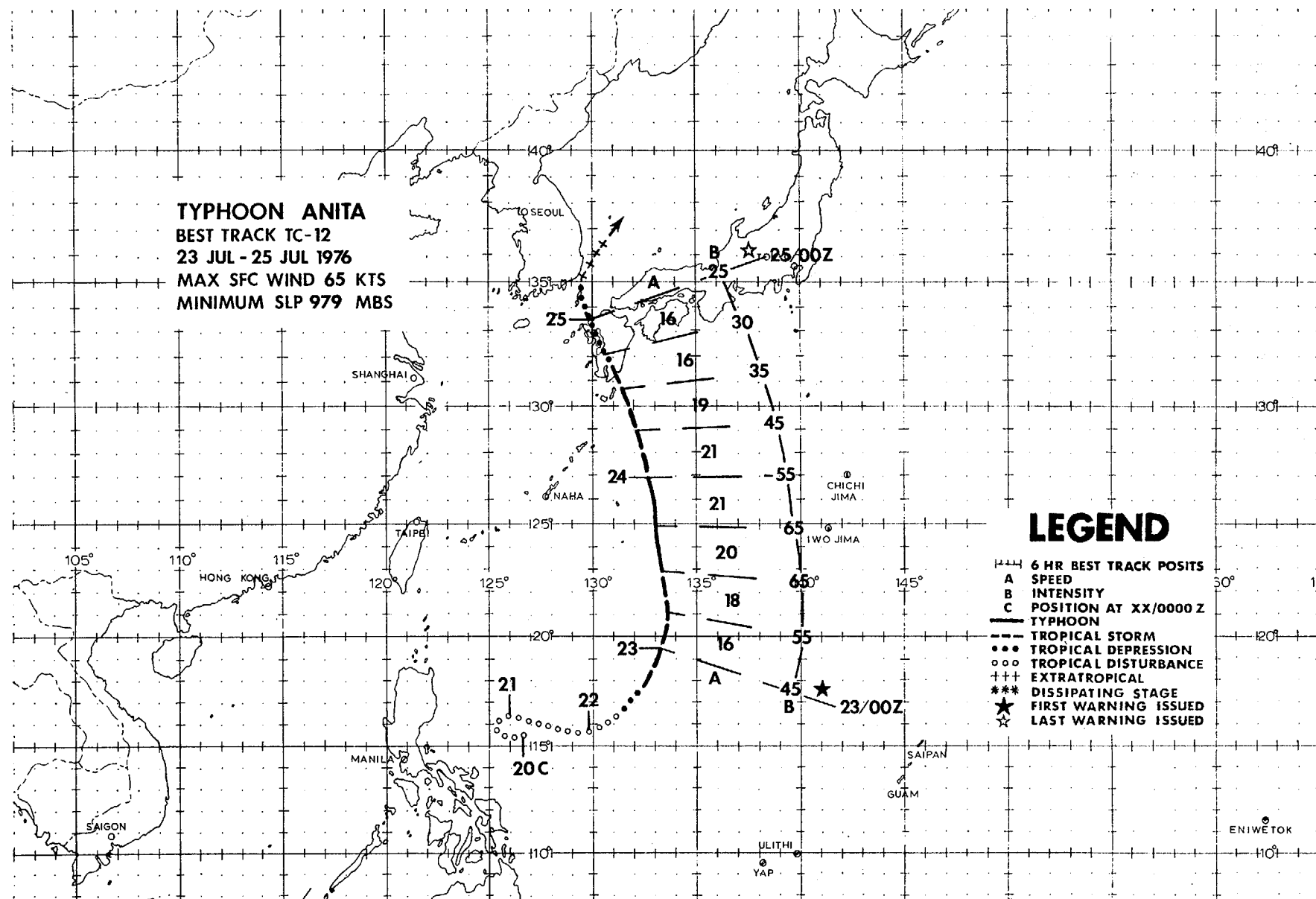


FIGURE 4-23. Typhoon Therese near 115 kt undergoing explosive deepening 260 nm south-east of Guam, 12 July 1976, 2104Z. (DMSP imagery)



FIGURE 4-24. Infrared photograph of Typhoon Therese at 90 kt intensity 90 nm northeast of Kadena AB, Okinawa, 17 July 1976, 1042Z. (DMSP imagery)



Anita had its inception in mid-July within the monsoon trough which was enhanced by cross equatorial flow at low levels. Three distinct surface circulation centers were evident on the 20th: one in the South China Sea which developed into Tropical Storm Violet; and two in the Philippine Sea which eventually became Tropical Storm Wilda and Typhoon Anita.

As early as the 18th, the weak circulation, which eventually developed into Anita, was tracked by satellite. Initially the disturbance moved slowly westward along the southern edge of the mid-tropospheric subtropical ridge, but by the 20th a break had developed in the ridge near 135E and extended northward to Japan. At the same time, a high pressure center was building northwestward from its center location over Mindanao, forcing a wedge between the disturbance located in the South China Sea and those in the Philippine Sea. In response to this ridging, the disturbance which would become Anita reversed course on the 21st and began to head eastward.

The synoptic pattern at the 200 mb level from the 18th through the 20th found the Tropical Upper Tropospheric Trough (TUTT) positioned just north of the disturbances in the Philippine Sea. The flow around the trough initially suppressed the upper level outflow from the disturbances, however, by the 21st the trough began to recede northward, relieving the pressure. Midway through the 21st, a cyclonic cell within the TUTT moved into a position favorable to enhance the outflow of the disturbance which became Wilda, and duplicated this mechanism 24 hours later for Anita. On the 22nd, Wilda and Anita were developing simultaneously. They attained tropical depression character-

istics at 0600Z and 1200Z, respectively. By 1200Z Wilda had accelerated northward along the western side of the subtropical ridge, allowing Anita to develop independently at an accelerated pace. By 1800Z Anita had attained tropical storm intensity, and began to move through the weakness left by Wilda.

As Anita continued to intensify, the size of the storm remained relatively small. Aircraft reconnaissance on the 23rd found only a narrow band of strong winds near the storm center. As Anita progressed northward through the weakness, it continued to intensify, reaching a peak of 65 kt and a minimum sea level pressure near 979 mb at 1200Z on the 23rd. The NOAA-4 satellite picture at 1207Z on the 23rd (Fig. 4-25) caught Anita at its peak intensity with a ragged eye discernible between two interlocking convective bands.

About the time Anita attained typhoon intensity, it also began to accelerate northward on a path similar to that taken by Wilda. With this acceleration, Anita was again thrust under the influence of unidirectional shearing. This suppressed Anita's outflow and contributed to loss of vertical stacking. The shear persisted for the duration of Anita's life, forcing the system to weaken almost as fast as it had developed. Anita's typhoon intensity lasted only 12 hours. Satellite data at 2214Z on the 23rd indicated that the storm had lost most of its hard core convection (Fig. 4-26). Thus, Anita was downgraded to a tropical storm at 0000Z on the 24th. As the system sped northward at 20 kt, it continued to weaken crossing western Kyushu late on the 24th with minimal tropical storm intensity. On the 25th, the remains of Anita entered the Sea of Japan and became extratropical at 0600Z while moving northward at 14 kt.

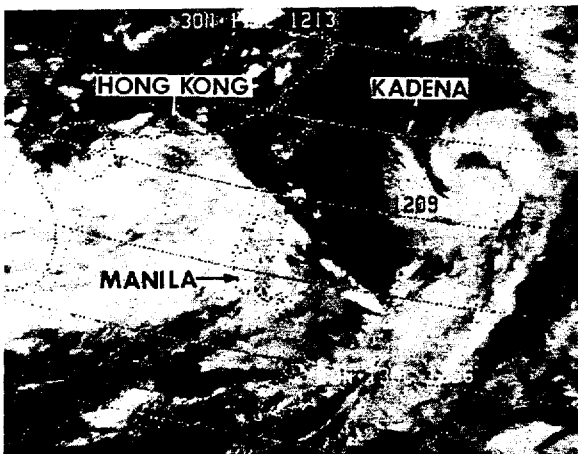


FIGURE 4-25. Inverted infrared photograph of Typhoon Anita (right) at peak intensity 360 nm southeast of Kadena AB, Okinawa. At left Tropical Storm Violet approaches the China coast, 23 July 1976, 1209Z. [NOAA-4 imagery]

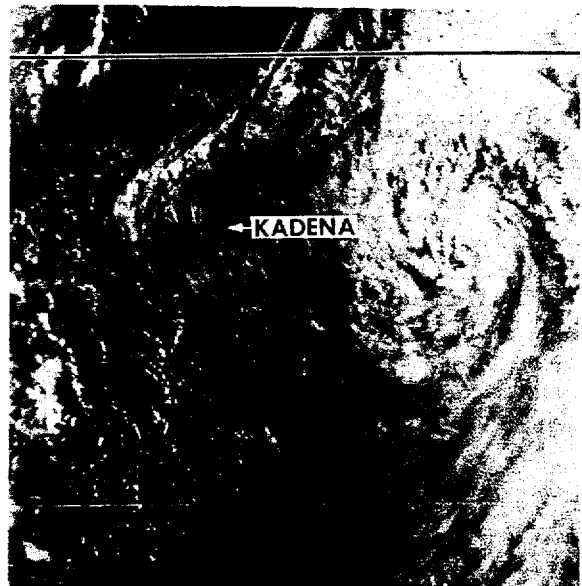
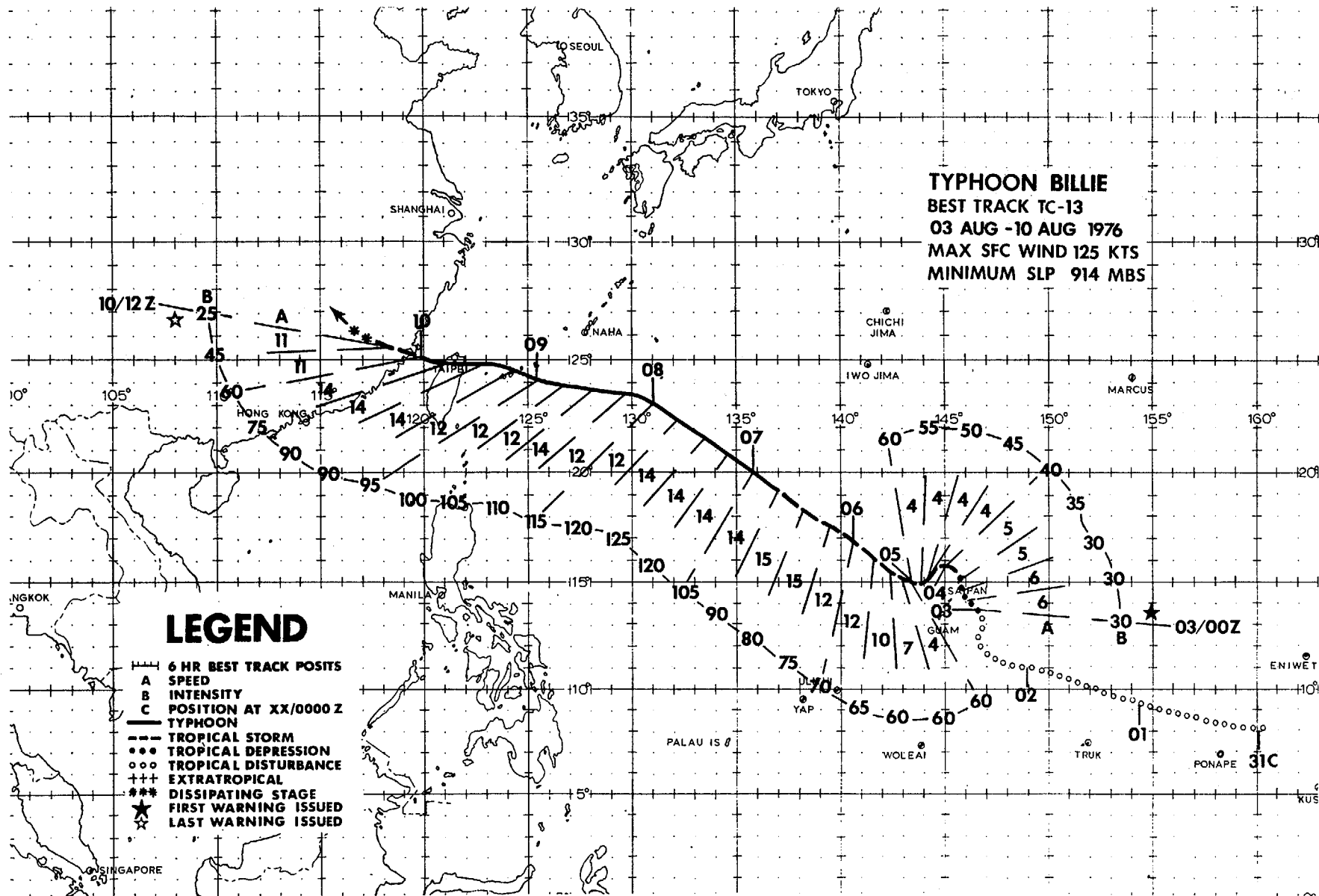


FIGURE 4-26. Anita at 60 kt intensity 270 nm east of Kadena AB, Okinawa, 23 July 1976, 2214Z. [DMSP imagery]



BILLIE

Billie, the 9th typhoon of the season, was first observed on the morning of July 31st as a disturbance in the near equatorial trough approximately 180 nm northeast of Ponape. During the subsequent two days the system demonstrated little intensification as it moved toward the west-northwest at 14 kt. Throughout this period poor vertical stacking and unidirectional flow through the system in the 300 mb to 200 mb region hindered development.

On the evening of 2 August, meteorological satellite data indicated that the disturbance had turned toward the north and was becoming better organized. By the morning of the 3rd, the convective system had consolidated and had acquired strong banding from the northeast and southwest (Fig. 4-27). At 0000Z on the 3rd the disturbance was placed into warning status as TD 13 centered about 100 nm east of Guam. Ship reports at 0000Z indicated 30 knot surface winds and aircraft at 0052Z reported 40 kt flight level (700 mb) winds from the south, 20 nm east of the depression center.

By late morning on the 3rd, the northward movement of the tropical system had positioned it near the southern periphery of the mid-tropospheric subtropical ridge. In response, the tropical depression turned sharply toward the northwest in the direction of Saipan. Between 1700Z and 1800Z on the 3rd, TD 13 passed over Saipan where the 1800Z synoptic reports indicated southwesterly winds at 15 kt, a sea level pressure of

999.8 mb and a 6-hour rainfall of 3.86 inches. At 1800Z the depression was designated Tropical Storm Billie.

By 0000Z on the 4th the storm had intensified to 40 kt, and the northwestward track changed to a 4 kt southwestward track. Since the 3rd an intense low cell in the Tropical Upper Tropospheric Trough (TUTT) was slowly propagating southwestward toward the storm. By the 4th this low cell and its associated trough was applying considerable southward pressure on the anticyclone above Billie. By this time the upper, middle and lower components of the storm were strongly coupled and the entire storm moved southwestward with the anticyclone. Billie continued to slowly intensify as outflow in all but the northeast quadrant remained good.

During this period of erratic movement it appeared that Billie would be a threat to Guam. However, by the afternoon of the 5th the TUTT began to rapidly recede to the northwest. This affected the storm in two ways: (1) It relieved the southwestward pressure allowing the storm to acquire a westward and ultimately a northwestward track; and (2) It allowed the low cell within the TUTT to move north of Billie, restricting outflow and temporarily slowing the intensification rate. By the 6th, the upper low had moved considerably westward, eliminating its restricting influence on the tropical cyclone. Billie reacted by accelerating on a northwestward track and attaining typhoon intensity by 1800Z on the 5th (Fig. 4-28).

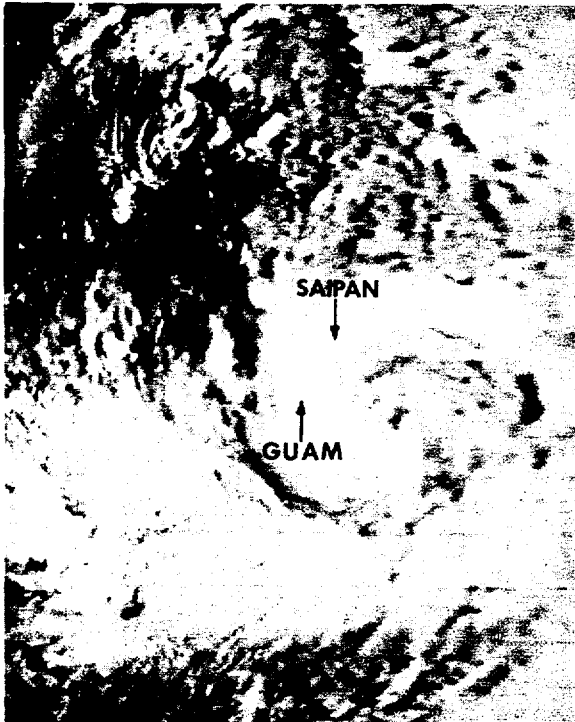


FIGURE 4-27. Billie during its early development at 30 kt intensity 100 nm east of Guam, 2 August 1976, 2155Z.



FIGURE 4-28. Billie at minimal typhoon intensity 275 nm northwest of Guam, 5 August 1976, 2118Z. [DMSP imagery]

During the subsequent 2 days Typhoon Billie continued its trek toward the north-west at 12 to 15 kt. Throughout this period outflow above the typhoon was unobstructed, allowing the system to intensify rapidly. From the night of the 6th until the morning of the 7th Billie underwent explosive deepening as an upper level trough west of the cyclone enhanced outflow in the northern semicircle and an unrestricted channel to the Southern Hemisphere subtropical jet stream enhanced outflow in the south semicircle. Reconnaissance aircraft at 1448Z on the 6th and at 0340Z on the 7th indicated that during this 13 hour period the eye temperature at 700 mb rose from 17°C to 26°C, and that the central pressure had fallen 46 mb, a rate more than 3.5 mb per hour. The 914 mb reported at 0350Z on the 7th was the minimum pressure attained by Billie. During this reconnaissance flight maximum surface winds were estimated to be 120 kt. At 0800Z on the 7th a ship, JPLY, reported southwesterly winds of 50 kt and a minimum sea level pressure 992.3 mb while located 70 nm south-southeast of the typhoon (Fig. 4-29). At 1200Z on the 7th Typhoon Billie reached its maximum intensity of 125 kt.

By the morning of the 8th the upper level trough, which had been located to the west of Billie, had been forced east of the typhoon by the rapid eastward expansion of a massive Asian upper level anticyclone. This upper level synoptic pattern exposed the region north of Billie to strong north-easterly flow which drastically reduced the outflow to the north and dictated a more westward movement for the tropical cyclone. This synoptic pattern persisted throughout the remainder of the storm's life, causing it to weaken and to move in a westward direction at 11 to 14 kt until it dissipated over mainland China.

By 0000Z on the 9th Billie had moved into the southern Ryukyu Islands. Fig. 4-30 illustrates surface observations from 0000Z through 1000Z on the 9th at the island stations of Miyako Jima (47927) and Ishigaki Shima (47918). Miyako Jima reported its lowest sea level pressure 964.4 mb at 0400Z while experiencing 44 kt sustained winds.

Two hours later Ishigaki Jima reported a pressure of 952.0 mb and northwesterly winds of 45 kt. At about 0700Z Typhoon Billie passed over the northern tip of Ishigaki Jima with maximum winds estimated at 95 kt,



FIGURE 4-29. Typhoon Billie at 115 kt intensity 300 nm southeast of Kadena AB, Okinawa, 7 August 1976, 2236Z. (DMSP imagery)

<div style="display: flex; align-items: center;"> <div style="border: 1px solid black; width: 40px; height: 40px; margin-right: 5px; position: relative;"> TIME STATION </div> <div style="text-align: center;">z</div> </div>	FWC/JTWC GUAM											DATE 09 AUG 1976
	09/00	09/01	09/02	09/03	09/04	09/05	09/06	09/07	09/08	09/09	09/10	
47927 ROMY MIYAKUJIMA	27 3/4 654 26 722	27 4/4 655 26 644	27 6 7 26 668	27 6 8 26 662	27 1 644 26 644	26 6 655 25 668	26 6 655 25 668	26 7 655 25 668	26 7 655 25 668	26 8 655 25 668	26 8 655 25 668	C
47918 ROIG ISHIGAKIJIMA	26 3/4 833 25 -611			26 3/4 833 25 -611		27 1 587 25 -611	27 1 587 25 -611			27 1 587 25 -611		C

FIGURE 4-30. Available synoptic surface observations at Miyako Jima and at Ishigaki Jima during the passage of Typhoon Billie.

and two hours later the island reported southwesterly winds of 91 kt with gust to 108 kt (Fig. 4-31). Newspaper reports stated that "huge waves south of Japan drowned 41 fisherman and swimmers along Japan's Pacific coast."

After its destructive whirl through the Ryukyus, Billie headed for Taipei traveling westward at 14 kt (Fig. 4-32). At 1200Z on the 9th, Penkiayu (46695) reported north-easterly winds of 77 kt. Taipei International Airport experienced 30 kt sustained winds with gusts to 65 kt, and a sea level pressure of 957.3 mb was observed at 1600Z; about one hour later the eye passed just south of Taipei.

Typhoon Billie exited Taiwan near Hsin-chu and moved toward the People's Republic of China on a west-northwestward track. By the morning of the 10th Billie had weakened into a tropical storm and slowed to 11 kt. At 0000Z on the 10th P'ing-t'an (58944) reported 60 kt winds from the north-northeast and a sea level pressure of 981.2 mb. About 0300Z Billie went ashore 25 nm southeast of P'ing-t'an. Within hours the storm had dissipated over the rugged terrain of eastern China.

Billie's passage over Taiwan was highly destructive (Fig. 4-33). Reports indicated 4 dead, 24 injured and 8 missing. Nearly 1000 homes were destroyed in the onslaught. Three ships were sunk and 7 others were severely damaged. Damage to power transmission facilities was estimated at \$2,630,000.

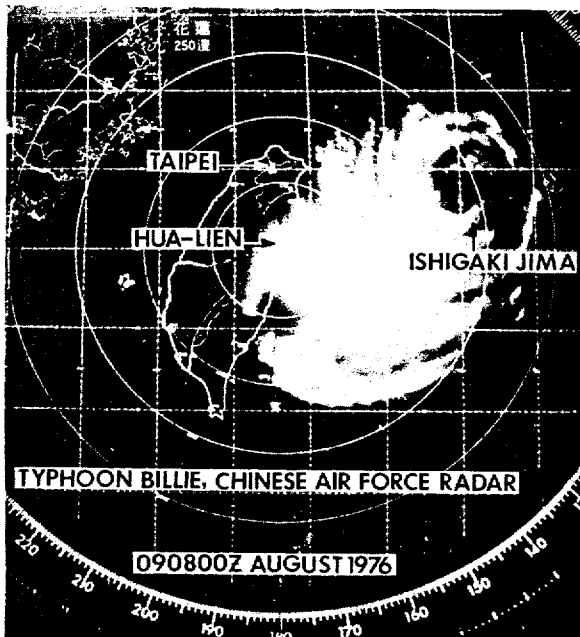


FIGURE 4-31. Radar presentation of Typhoon Billie as it pounds Ishigaki Jima with 90 kt winds, 150 nm east of Taipei, 9 August 1976, 0800Z. (Photograph courtesy of the Central Weather Bureau, Taipei, Taiwan, Republic of China.)

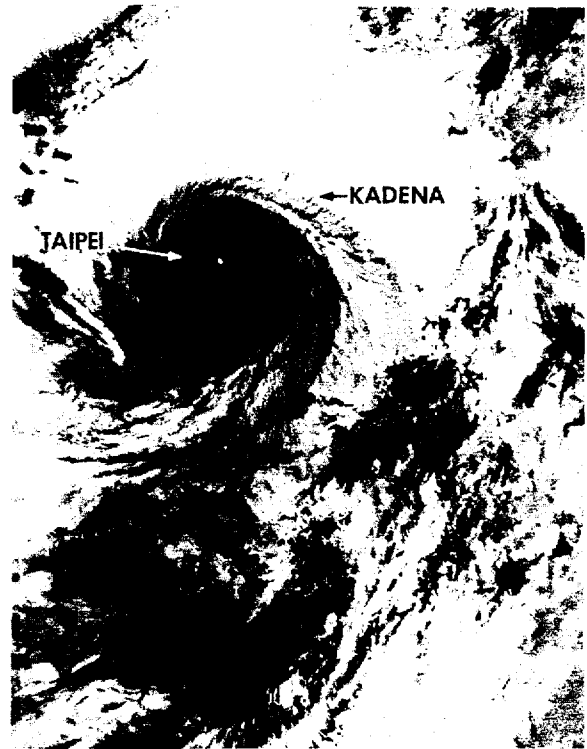
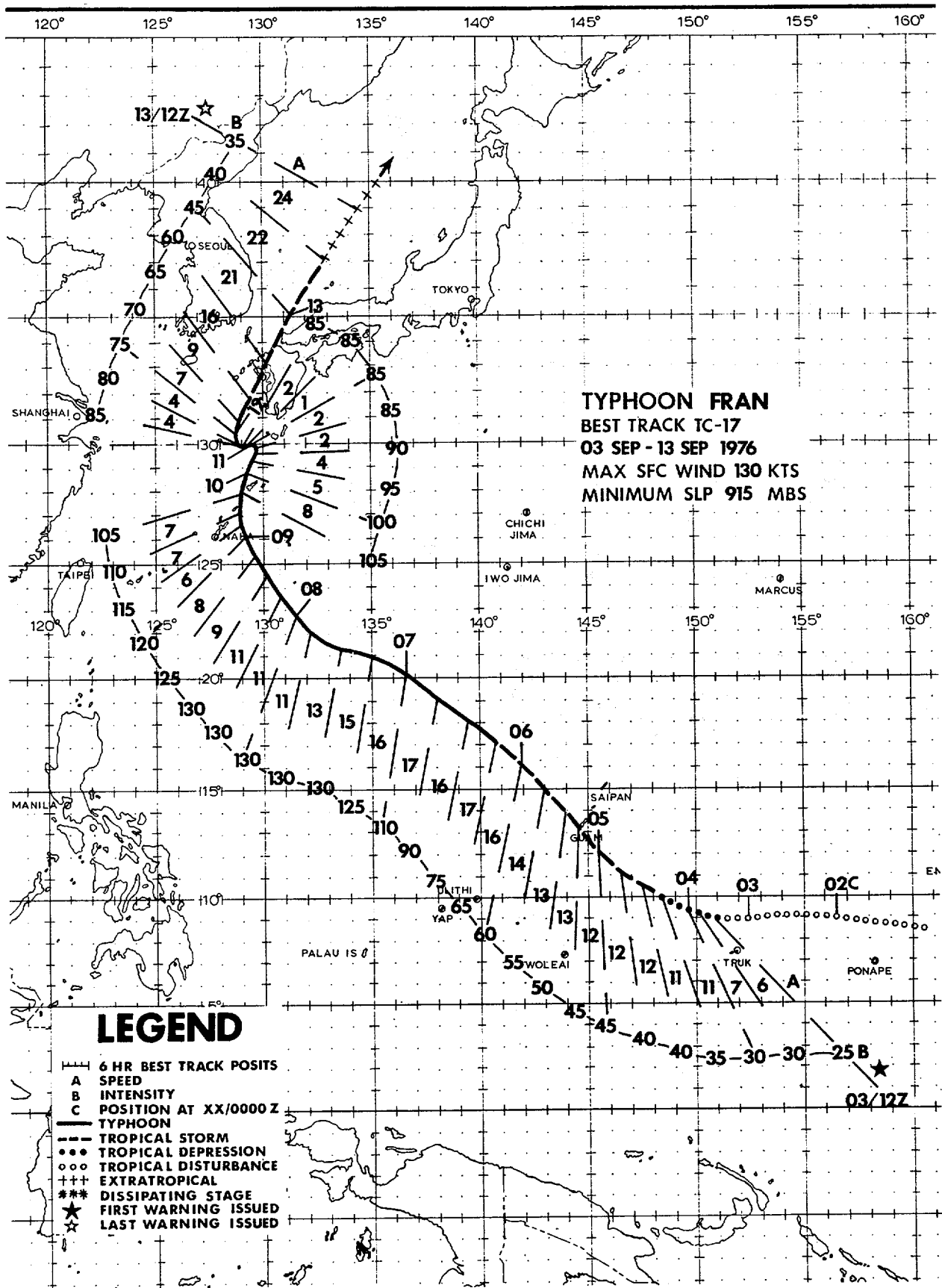


FIGURE 4-32. Infrared photograph of Typhoon Billie exiting the southern Ryukyu Islands with 90 kt intensity, 95 nm east of Taipei, 9 August 1976, 1109Z. (DMSP imagery)



FIGURE 4-33. Downtown Taipei after Typhoon Billie lashed the city with 75 kt winds. (Courtesy of Central Weather Bureau, Taipei, Taiwan, Republic of China.)



FRAN

Fran, the 17th storm of the season, began as an innocuous area of convective activity in the monsoon trough. Its life span of 10 days included development to super typhoon intensity and a destructive passage through the Japanese archipelago.

First detected on the afternoon of the 1st of September as an area of convective activity 200 nm northeast of Ponape, the system was monitored for 2 days before exhibiting any significant development. The initial warning on TD 17 was issued at 1200Z on the 3rd after satellite data indicated the disturbance had strengthened, and further intensification was expected. The depression was upgraded to Tropical Storm Fran after reconnaissance aircraft at 0339Z on the 4th recorded a central pressure of 997 mb. Aircraft data further indicated that the storm was heading northwestward at 11 kt. Mid-tropospheric synoptic data showed a weakness in the subtropical ridge south of Japan, toward which Fran was moving.

By 0000Z on the 5th the storm was 90 nm south of Guam, continuing on its northwestward track. Nine hours later Fran passed 20 nm west of Guam. A maximum sustained wind of 30 kt with gusts to 41 kt was reported on the island. By the morning of the 6th Fran had intensified to 60 kt while moving toward the northwest at 14 kt (Fig. 4-34). At 0245Z

aircraft reported that the storm was some 250 nm north-northwest of Guam. During this reconnaissance flight maximum surface winds were estimated at 65 kt and a circular eye 30 nm in diameter was observed. Based on this information and a recorded central pressure of 977 mb, Tropical Storm Fran was upgraded to a typhoon.

As Fran reached typhoon intensity, upper tropospheric data indicated development of two anticyclones to the north and east of the storm which acted to suppress outflow from the northeast semicircle of the typhoon. By the morning of the 7th the anticyclones had dissipated, allowing unhindered outflow. This outflow was enhanced by the deepening of a short wave trough over central China which produced a highly efficient link to the mid-latitude westerlies. In response Fran began to deepen explosively. On the 7th at 0307Z reconnaissance aircraft recorded a central pressure of 916 mb and observed maximum surface winds estimated at 130 kt. During the previous 12 hours the central pressure dropped 43 mb, a rate of 3.6 mb per hour.

For 24 hours the upper tropospheric outflow remained unhindered, permitting the storm to maintain its maximum 130 kt super typhoon intensity (Fig. 4-35). On the 7th at 2109Z the central pressure reached its



FIGURE 4-34. Fran at 60 kt intensity 190 nm northwest of Guam, 5 September 1976, 2150Z. (DMSP imagery)

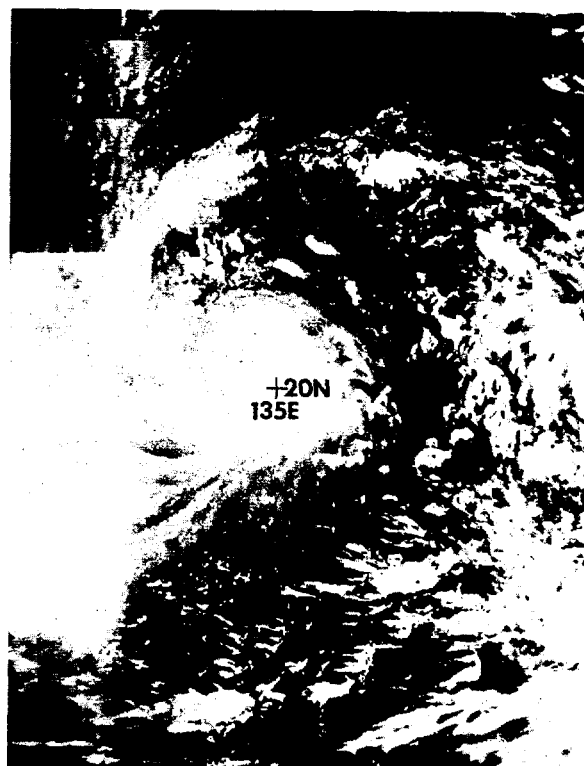


FIGURE 4-35. Moonlight photograph of Super Typhoon Fran with winds near 130 kt 450 nm southeast of Kadena AB, Okinawa, 7 September 1976, 1023Z. (DMSP imagery)

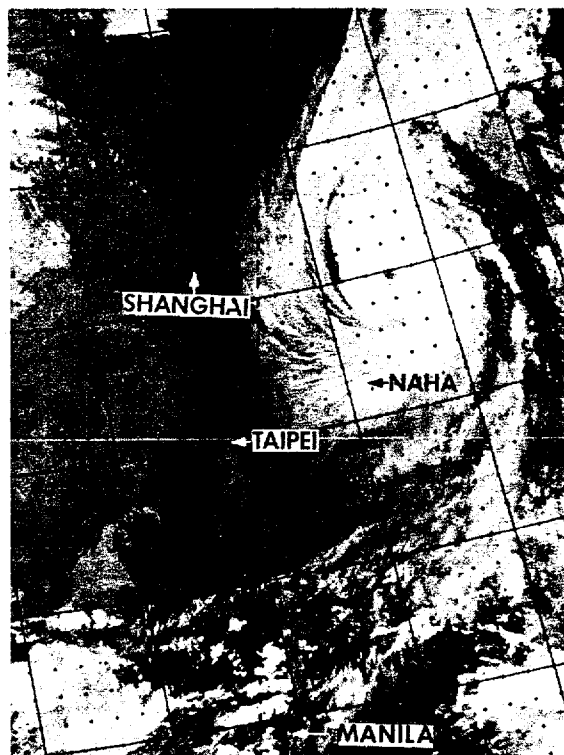


FIGURE 4-36. Inverted infrared photograph of Typhoon Fran during period of erratic movement with 90 kt intensity 210 nm north-northeast of Kadena AB, Okinawa, 10 September 1976, 1129Z. (DMSP imagery)

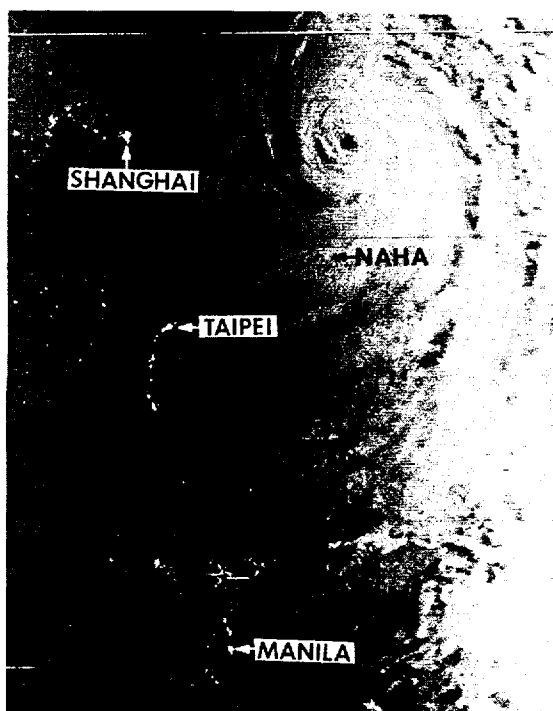


FIGURE 4-36a. Moonlight visual presentation of Figure 4-36. Bright areas are city lights and bright horizontal lines are lightning discharges. (DMSP imagery)



FIGURE 4-36b. Figure 4-36a expanded.

lowest observed level of 913 mb.

As the short wave trough northwest of Fran moved eastward, northeasterly flow from the upper level Asian anticyclone began to hinder outflow in the western semicircle of the storm. Consequently, by the evening of the 8th the storm had weakened to 125 kt, and had begun to move northward in response to the retrogression of an upper tropospheric short-wave trough to a position west of the storm.

As Fran traveled through the Ryukyu Islands, it passed 60 nm east of Okinawa. Naha (47930) recorded a maximum sustained surface wind of 55 kt with gusts to 73 kt. Some damage was experienced at Kadena AB on Okinawa.

By the evening of the 10th Fran had slowed to 2 kt (Fig. 4-36, Fig. 4-36a, and Fig. 4-36b), and during the subsequent 36 hours drifted on an erratic path toward the west. On the night of the 11th Fran began to accelerate northward (Fig. 4-37) and by the following morning was moving toward the north-northeast at 7 kt. These irregular movements were apparently in response to east-west oscillations of the upper tropospheric short-wave trough north of the storm.

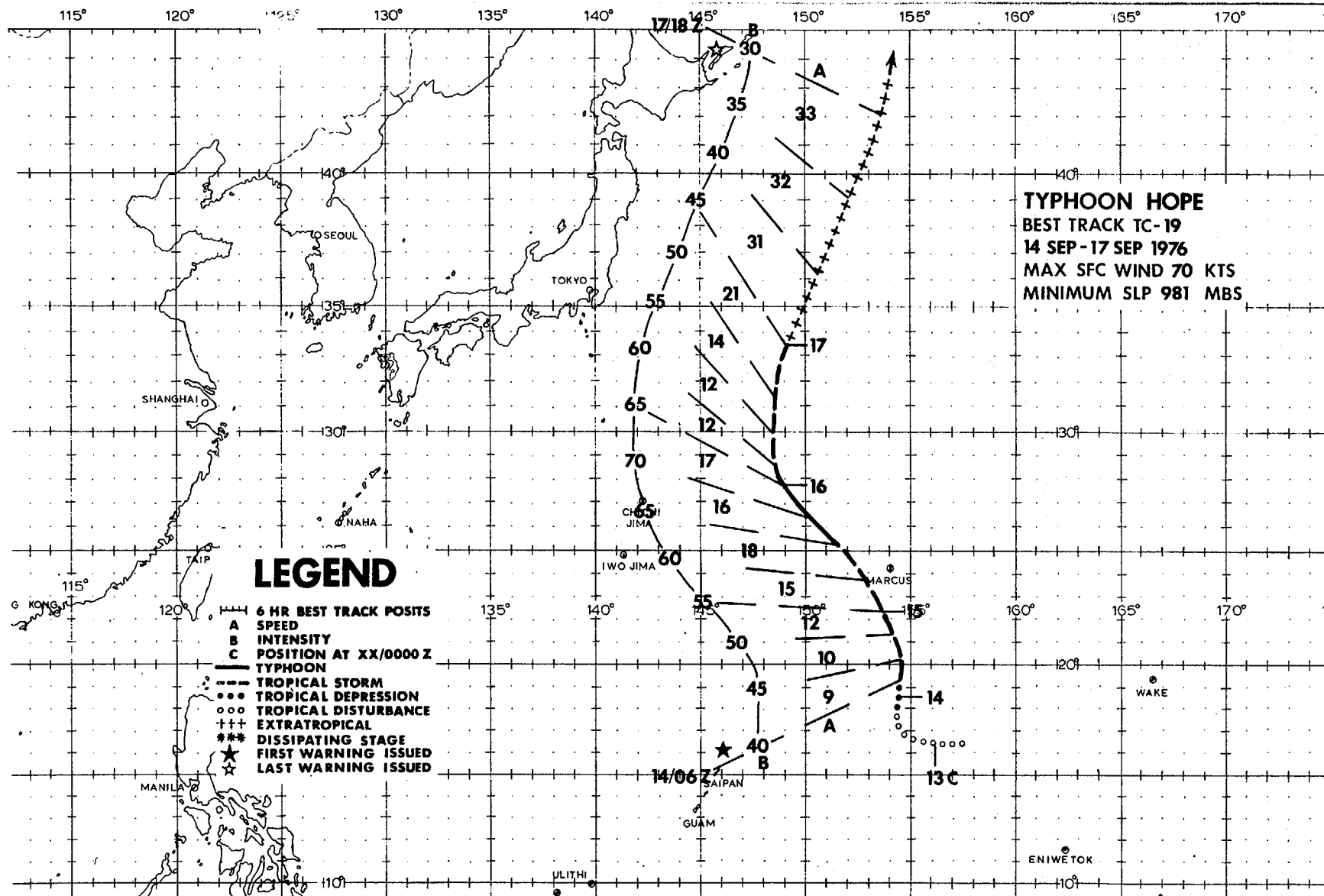
During this period of slow, erratic movement the storm's destructive winds caused several maritime mishaps. JICS, a ship of Panamanian registry, ran aground at Tibjima, Minamata Bay on September 12th and the Kyoyu Maru reportedly broke in two in the Bungo Straits on the 11th.

On the afternoon of the 12th the storm accelerated and moved toward the north-northeast in response to a deepening upper tropospheric trough over central China. Passing over Kyushu on the evening of the 12th, Typhoon Fran had weakened to tropical storm intensity. Twelve hours later, as the storm traveled over the cooler Sea of Japan, it lost its tropical features becoming extratropical at 0600Z on the 13th.

Typhoon Fran's slow movement through the Tokara Island group, over Kyushu, and into the Sea of Japan caused significant damage and loss of life. It was reported to be the most destructive tropical cyclone affecting Japan in the last 10 years. The Japanese National Police Agency confirmed a total of 133 persons dead, 32 missing and 227 injured as a result of Fran's torrential rains and strong winds. According to the Japan Times of 15 September, damage to private and public facilities was estimated at approximately \$572 million.



FIGURE 4-37. Infrared photograph of Typhoon Fran at 75 kt 190 nm south-southwest of Sasebo, 11 September 1976, 1116Z. (DMSP imagery)



HOPE

Hope, the 11th typhoon of the season, developed in a region of intense cyclonic shear produced by a deep southwesterly monsoon surge. Not since August 1974, during the similar development of Typhoon Mary, has the western Pacific experienced such a deep and prolonged southwesterly monsoon flow. The disturbance soon to become Typhoon Hope was first detected near 17N-157E on the morning of the 13th of September as a region of deep, but unorganized, convection at the eastern edge of the intense monsoon trough. This same trough had spawned Tropical Storm Georgia four days earlier.

By the following morning the disturbance exhibited much better organization (Fig. 4-38) and a Tropical Cyclone Formation Alert was issued at 0044Z on the 14th. At 0600Z the American Chieftain (WJNA) 125 nm north-east of Hope, reported 45 kt southeasterly winds and a minimum sea level pressure of 998.7 mb. Some 200 nm south-southeast of the system, the American Lynx (WZJE) reported 40 kt winds from the southwest and a minimum sea level pressure of 998.8 mb. The first warning on Tropical Storm Hope was issued at 0702Z.

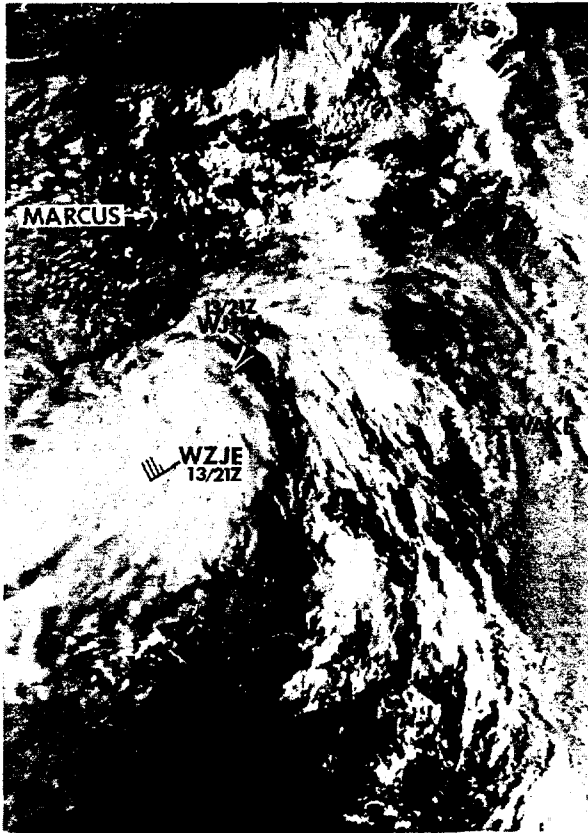


FIGURE 4-38. Hope approaching tropical storm intensity 340 nm south of Marcus, 13 September 1976, 2013Z. Gale force winds were observed in the east semicircle of the system illustrating the intensity of the monsoon trough. (DMSP imagery)

Reconnaissance aircraft at 0847Z on the 14th indicated a central pressure of 995 mb and testified to the large asymmetrical character of this cyclone. Maximum winds in the western quadrant were found to be only 20 kt while ships in the east semicircle reported winds of 45 kt 250 nm from the storm.

During the subsequent 2 days Hope accelerated to the north-northwest toward a weakness in the mid-tropospheric subtropical ridge, a weakness created by the combined effects of a 500 mb trough located above Japan and an active Tropical Upper Tropospheric Trough (TUTT), oriented northeast-southwest, west of Marcus Island. At 0240Z on the 14th reconnaissance aircraft observed the minimum recorded sea level pressure of 981 mb and indicated that the north-northwestward movement of Hope had increased to 15 kt. At 0300Z, Marcus Island reported maximum sustained surface winds of 54 kt, a minimum sea level pressure of 988.6 mb and a 3-hourly pressure fall of 7.7 mb as the typhoon passed 90 nm south-southwest.

Hope attained its maximum intensity of 70 kt about 1800Z on the 15th, approximately 240 nm northwest of Marcus (Fig. 4-39). During the morning of the 16th Typhoon Hope began to weaken as it slowed to 12 kt and began to traverse the mid-tropospheric subtropical ridge. Twenty-four hours later the storm had weakened to 45 kt and was moving toward the north-northeast at a speed in excess of 30 kt. The final warning was issued at 1800Z on the 17th when strong shear, cooler sea surface temperatures, and incursion of cool air had stripped Hope of its tropical nature.

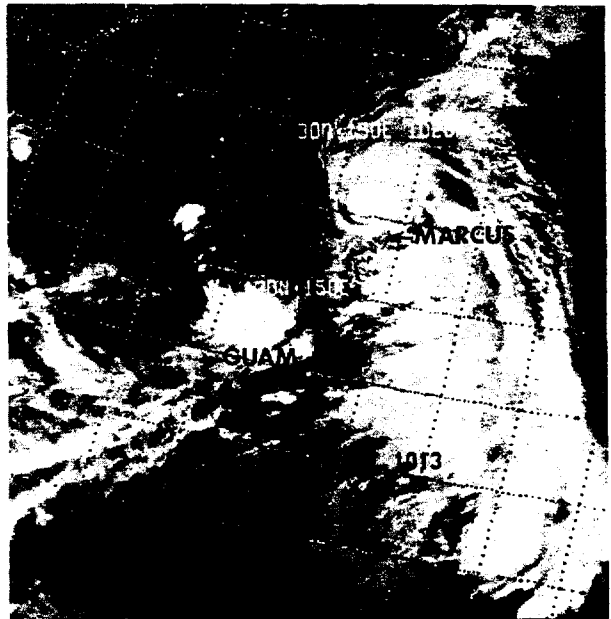
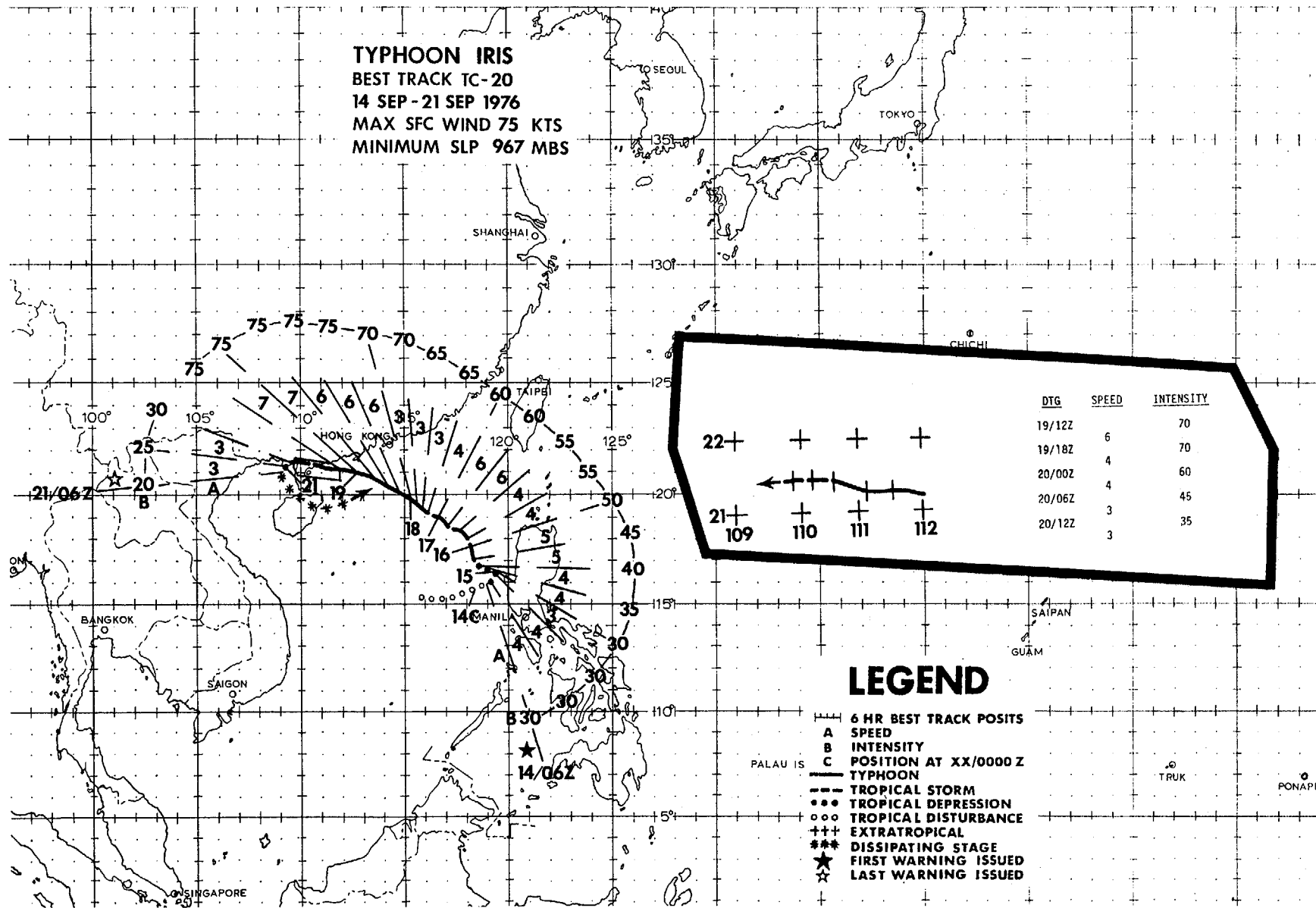


FIGURE 4-39. Inverted infrared photograph of Hope approaching typhoon intensity 110 nm west-northwest of Marcus, 15 September 1976, 1018Z. The remnants of Tropical Storm Georgia appear northeast of Guam. (NOAA-4 imagery)

TYPHOON IRIS
BEST TRACK TC-20
14 SEP-21 SEP 1976
MAX SFC WIND 75 KTS
MINIMUM SLP 967 MBS



On the 13th of September satellites gave the first indications of what was to become the only typhoon of the year to originate in the South China Sea. At 0140Z on the 14th a tropical cyclone formation alert was issued for an area west of Manila, and at 0600Z the first warning on TD 20 was issued.

During this period the synoptic situation was characterized by low pressure over Southeast Asia and an enhanced southwest monsoon over the southern South China Sea. At the mid-tropospheric level short wave troughs were passing from west to east well north of the storm. With a lack of significant steering flow TD 20 began to drift slowly northward. By 0600Z on the 15th satellite and synoptic data indicated some intensification, and the tropical depression was upgraded to Tropical Storm Iris (Fig. 4-40).

By the evening of the 16th, a weak mid-tropospheric ridge had begun to build north of Iris causing the storm to turn northwestward toward southern China. An upper tropospheric trough northwest of Iris enhanced outflow to the north, allowing the system to intensify to typhoon intensity by 0600Z on the 17th. Aircraft reconnaissance at 0420Z observed typhoon strength surface winds 40 nm southeast of the storm center and recorded a central pressure of 983 mb. At 1200Z Pratas Island (59981) recorded winds of 40 kt and a sea level pressure of 997.3 mb.

Three hours later, Iris with maximum winds of 75 kt passed 90 nm south-southwest of the island. At 2100Z Pratas recorded a minimum sea level pressure of 997.1 mb and winds of 33 kt. As Iris continued toward the south-eastern coast of Asia it became further influenced by the subtropical ridge to the north, the typhoon turned more westward and accelerated to 7 kt (Fig. 4-41). At 0600Z on the 19th Iris, still maintaining 75 kt winds, passed 35 nm south of Shan-Ch'uan-Tao (59673) where the station reported a sea level pressure of 988.1 mb and winds of 60 kt.

Typhoon Iris made landfall 30 nm north of Chancian (59755) on the Luichow Peninsula at 2100Z on the 19th. The cyclone dissipated rapidly as it crossed the peninsula. Fifteen hours later it had weakened to a 35 kt tropical storm and entered the Gulf of Tonkin. The final warning was issued at 0600Z on the 21st.

On the 18th, Iris had passed 90 nm south of Hong Kong, where 68 kt winds were observed. Hong Kong newspaper reports indicated that more than a dozen people were injured by flying debris. Also on the 18th, 50 nm east of Pratas and 50 nm north of the storm, the Chieh Lee, a 5000 ton Panamanian freighter, sank. According to newspaper reports, 13 crewmen were rescued while 4 were known dead and 11 others were missing.

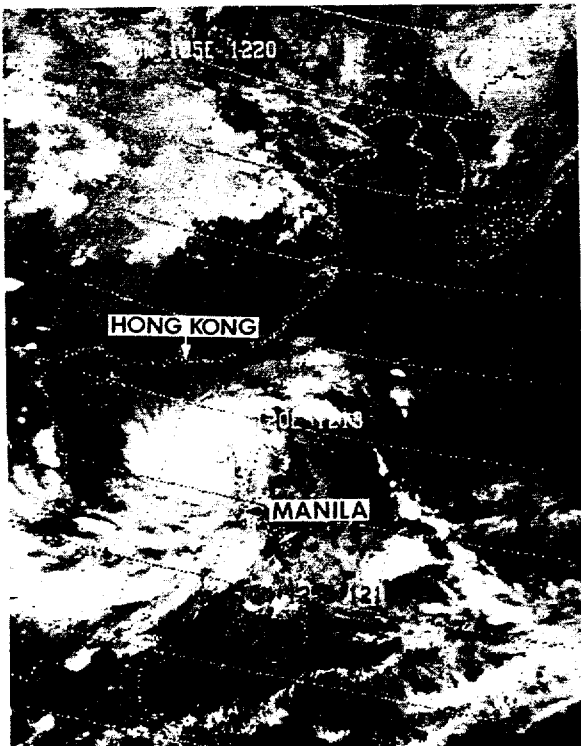


FIGURE 4-40. Inverted infrared photograph of Iris at 40 kt 195 nm northwest of Manila, 15 September 1976, 1212Z. (NOAA-4 Imagery)

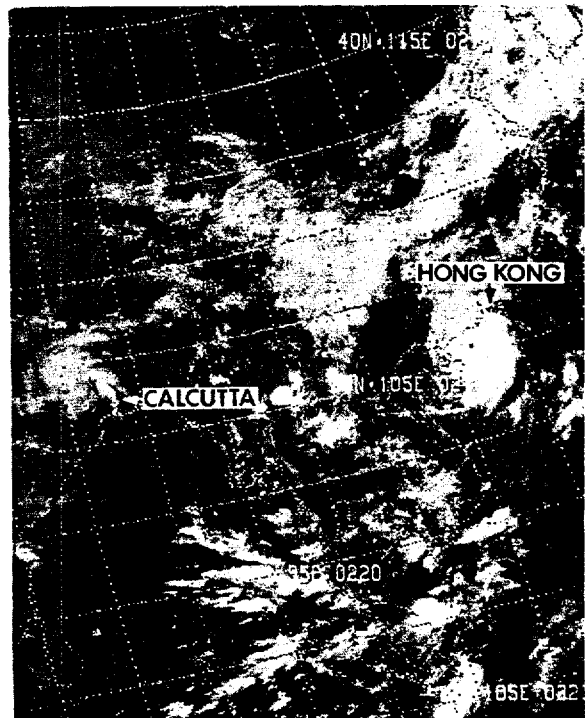
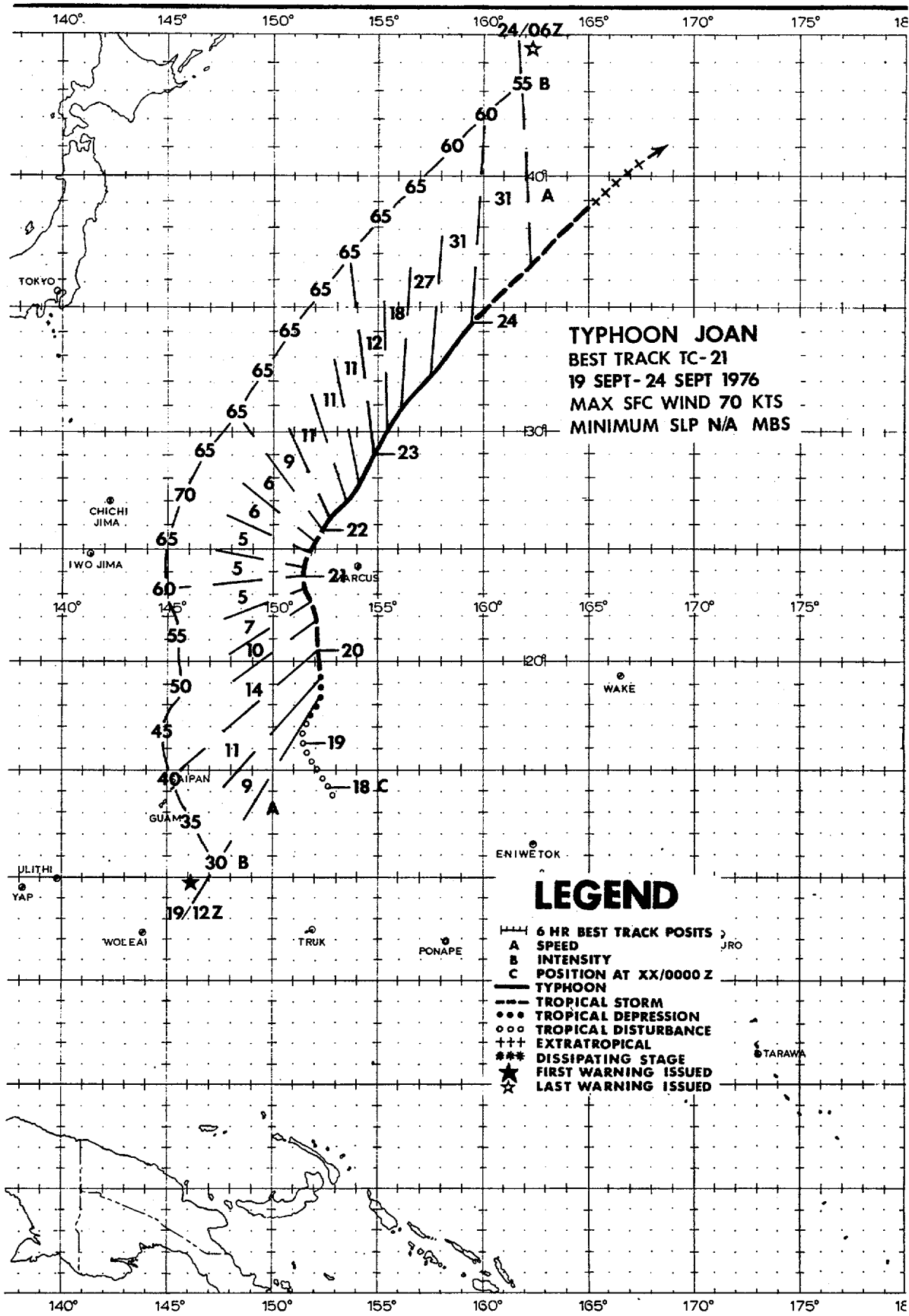


FIGURE 4-41. Typhoon Iris (right) at 75 kt peak intensity 110 nm southwest of Hong Kong, 19 September 1976, 0216Z. Tropical Cyclone 23-76 is seen inland over India. (NOAA-5 Imagery)



Destined to spend its entire life over the open ocean, Joan originated within an active near equatorial trough which extended from the coast of China across the western Pacific to the Marshall Islands. Joan was initially observed on the 17th of September as a tropical disturbance, with a weak surface cyclone centered near 13N 155E. At the time the disturbance was detected, the southwestern edge of a sharp Tropical Upper Tropospheric Trough (TUTT) was situated over the low level circulation creating unidirectional shear which suppressed growth of the upper level anticyclone above the system. By the 18th, the TUTT had receded northward allowing a small anticyclone to develop and permitting outflow to the west above the disturbance. By the 19th, the TUTT had receded even farther north allowing the anticyclone to fully develop and to generate outflow in all quadrants. With the outflow mechanism established, the disturbance intensified and became TD 21 on the 19th at 0600Z. At 1800Z on the 19th it was upgraded to Tropical Storm Joan, 325 nm south-southwest of Marcus Island (Fig. 4-42).

Initially, Joan tracked northward through a large break in the mid-tropospheric subtropical ridge which had persisted since the passage of Typhoon Hope the previous week. By the 20th, the ridge began to reestablish itself toward the northwest, forcing Joan to acquire a northwestward track during the subsequent 24 hours. During this period the

storm intensified at a rate of 5 kt per 6 hours. On the 21st, Joan slowed its forward speed to 5 kt. As it approached the western extremity of the subtropical ridge it became evident that Joan would recurve toward the northeast. At this point the storm had a well developed outflow pattern with several convective bands consolidating around a central dense overcast approximately 1 degree in diameter.

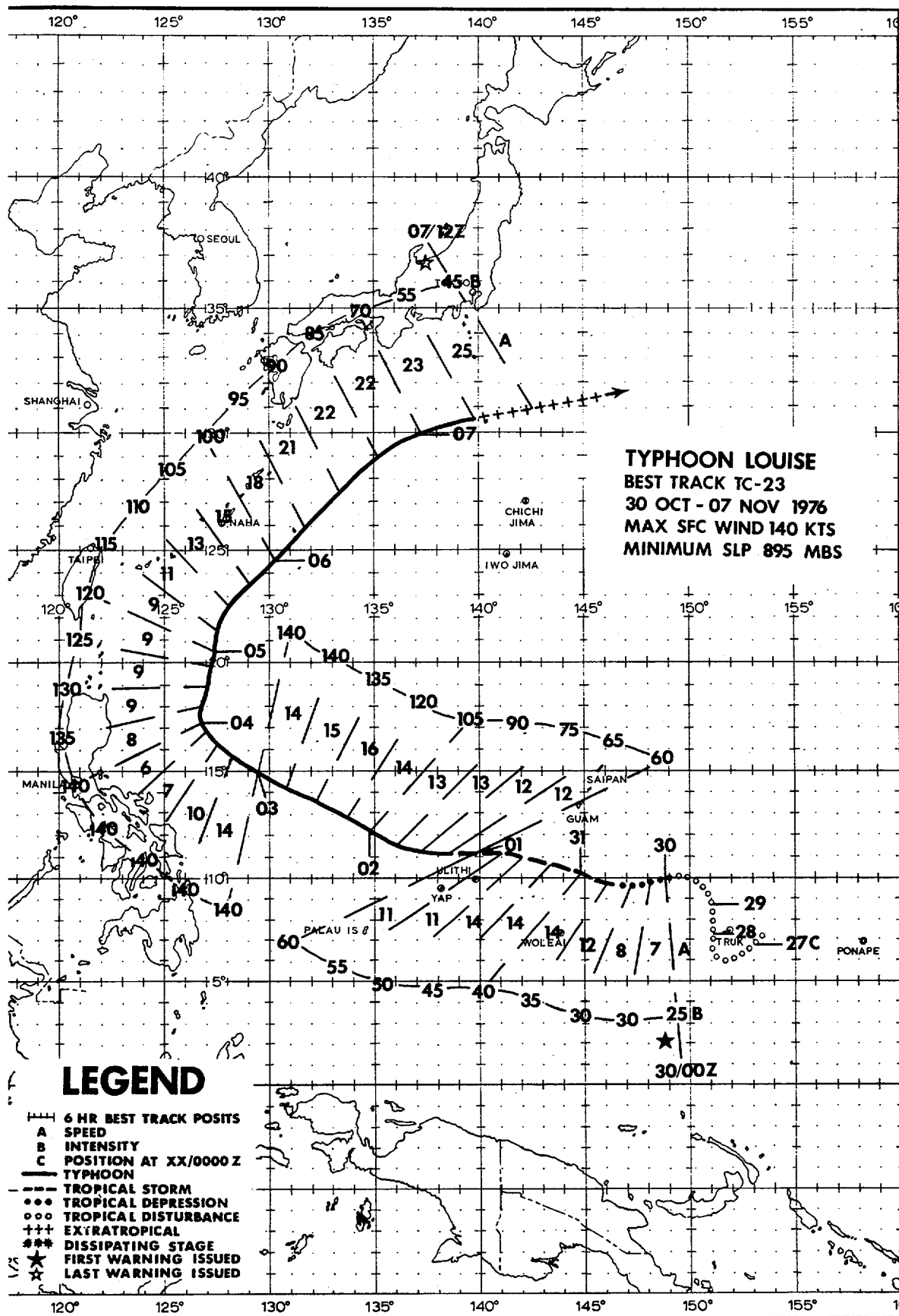
By 0600Z on the 21st, Joan had attained typhoon intensity while at the midpoint of recurvature. Six hours later, Typhoon Joan attained its peak intensity of 70 kt (Fig. 4-43), and a distinct, well defined eye was visible on satellite data with tightly wrapped convective bands surrounding the center. At 0000Z on the 21st Joan passed 125 nm west of Marcus Island where 33 kt surface winds were observed. By the 22nd Joan had weakened slightly but maintained typhoon intensity as it accelerated to 11 kt toward the northeast. Firmly implanted in the mid-latitude southwesterlies ahead of a long wave trough moving slowly across Japan, Joan continued to track northeastward accelerating to 31 kt by the 24th. It became an extratropical system at 1200Z on the 24th. The remains of Typhoon Joan continued to disrupt shipping lanes in the western Pacific. A ship, UWGR, at 1200Z on the 24th reported sustained winds of 65 kt and a sea level pressure of 975 mb while located near 38N 165E, 60 nm east of the extratropical low.



FIGURE 4-42. Joan just after attaining tropical storm intensity 300 nm south-southwest of Marcus, 19 September 1976, 2042Z. (DMSP imagery)



FIGURE 4-43. Infrared image of Typhoon Joan near its 70 kt peak intensity 130 nm west of Marcus, 21 September 1976, 0915Z. (DMSP imagery)



LOUISE

Louise, the 14th and final typhoon of season, was also the most intense of 1976. The disturbance that was to become Louise was first detected by satellite data on the morning of 27 October about 75 nm east of Truk. During the next 3 days the disturbance showed little intensification as it meandered through the northern Truk District. Late on the 29th the system began moving toward the west, and by the morning of the 30th satellite data indicated that it was intensifying (Fig. 4-44). The first warning was issued at 0000Z on the 30th as TD 23.



FIGURE 4-44. Louise a few hours prior to becoming TD 23 150 nm northwest of Truk and 400 nm southeast of Guam, 29 October 1976, 2107Z. (DMSP imagery)

Reconnaissance aircraft at 1515Z on the 30th indicated that the central pressure had fallen to 996 mb, and at 1800Z the depression was upgraded to Tropical Storm Louise. During the next 36 hours Louise moved west-northward at 14 kt, then westward at 11 kt as its winds increased at a rate of 5 kt every 6 hours. At 0311Z on the 1st of November aircraft observed 70 kt flight level winds and found that the central pressure of the storm had fallen to 976 mb. At 0600Z Louise was upgraded to a typhoon while 100 nm northwest of Ulithi Atoll.

Beginning on the 1st, a series of rapidly moving, mid-tropospheric short-wave troughs created a weakness in the subtropical ridge between 125E and 130E. On the afternoon of the 1st Louise began to respond to this weakness by acquiring a northward track. Almost simultaneously, the typhoon commenced more rapid deepening, attaining 105 kt winds by the morning of the 2nd. From 0311Z on the 1st to 0310Z on the 2nd reconnaissance aircraft indicated a fall in the central pressure of 43 mb, a rate of 1.8 mb per hour. This deepening was in response to favorable upper-level outflow channels to the northeast and south (Fig. 4-45). Further deepening to 905 mb had occurred by 1435Z on the 2nd, a fall of 28 mb in 11 hours.

During the early morning of the 3rd Super Typhoon Louise attained its maximum intensity of 140 kt which it maintained for nearly 36 hours (Fig. 4-46). The lowest recorded pressure was 895 mb observed by aircraft at 0830Z on the 3rd (Fig. 4-47).

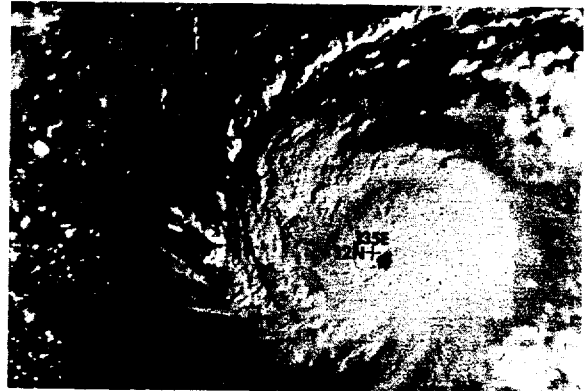


FIGURE 4-45. Typhoon Louise at 100 kt intensity 240 nm west-northwest of Yap, 1 November 1976, 2212Z. (DMSP imagery)

From the morning of 2nd until the afternoon of the 3rd Louise maintained its northward track moving at 14 to 16 kt. Then, on the afternoon of the 3rd, the storm slowed to 6 kt as it recurved around the western periphery of the mid-tropospheric subtropical ridge. By 0000Z on the 4th, Louise began to accelerate to 9 kt, moving in a north-northeastward direction and slowly weakening. Louise continued this movement for more than 30 hours as it traversed the broad axis of the subtropical ridge. Late on the afternoon of the 5th the typhoon, which had weakened to 115 kt, began to accelerate on a northeast track.

From 0000Z on the 4th until 1800Z on the 6th Louise weakened at the unusually slow rate of 5 kt per 6 hours. This slow weakening resulted from two conditions: (1) A broad surface high pressure cell centered over northern Honshu prevented significant



FIGURE 4-46. Super Typhoon Louise at 140 kt peak intensity 500 nm east of Manila, 2 November 1976, 2318Z. (DMSP imagery)



FIGURE 4-47. Infrared photograph of Typhoon Louise at peak intensity 380 nm east-northeast of Manila and 615 nm south of Kadena AB, Okinawa, 3 November 1976, 1045Z. (DMSP imagery)

equatorward penetration of frontal systems; and (2) The extremely strong jet stream (exceeding 200 kt) over eastern Japan provided an excellent outflow channel. At 0300Z on the 6th, Minamidaito Jima (47945), 40 nm north-northeast of Louise, reported east-northeasterly winds of 40 kt and a sea level pressure of 984.8 mb. Two hours later the storm passed 15 nm southeast of the island with maximum winds estimated near 95 kt.

By the 7th, cooler sea surface temperatures and very strong vertical shear were taking their toll as Louise moved north of 30N. Reconnaissance aircraft at 0359Z on the 7th indicated that Louise was rapidly losing its tropical character and was

becoming extratropical. The Airborne Reconnaissance Weather Officer also observed that the lower half of the wall cloud was "rotating rapidly", a phenomenon sometimes reported when a storm is becoming extratropical.

At 0600Z on the 7th, moving east-northeast at 25 kt, Louise became extratropical. As an extratropical system the remains of Louise moved northward to combine with another surface low. The resulting system had deepened to 947 mb by the 10th and became one of the most severe extratropical storms of the year, ultimately producing surf in excess of 30 ft in the Hawaiian Islands.

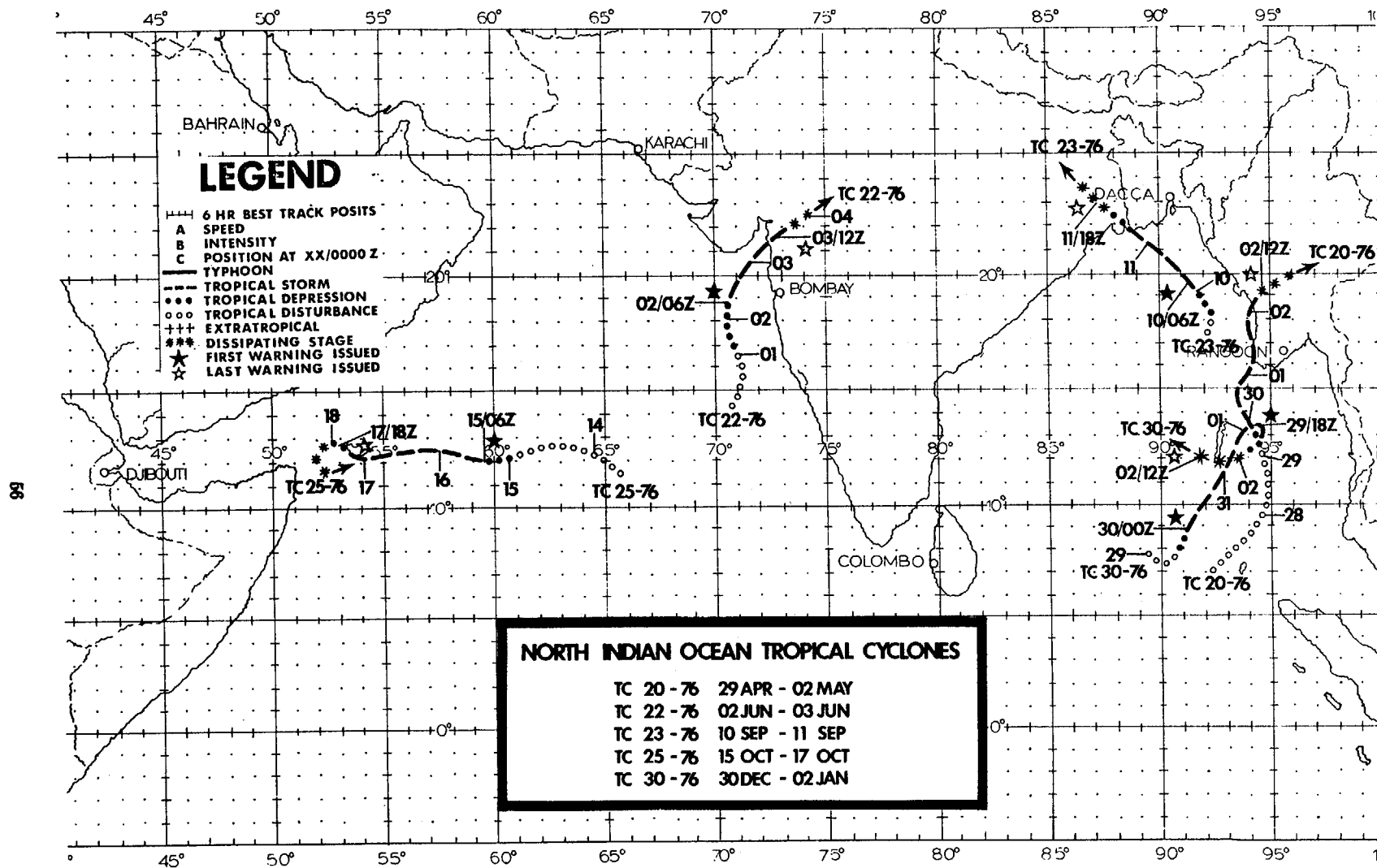




FIGURE 4-48. Tropical Cyclone 24-76 entering southwestern Burma coast with 55 kt peak intensity 110 nm west-southwest of Rangoon, 1 May 1976, 0150Z. (NOAA-4 imagery)

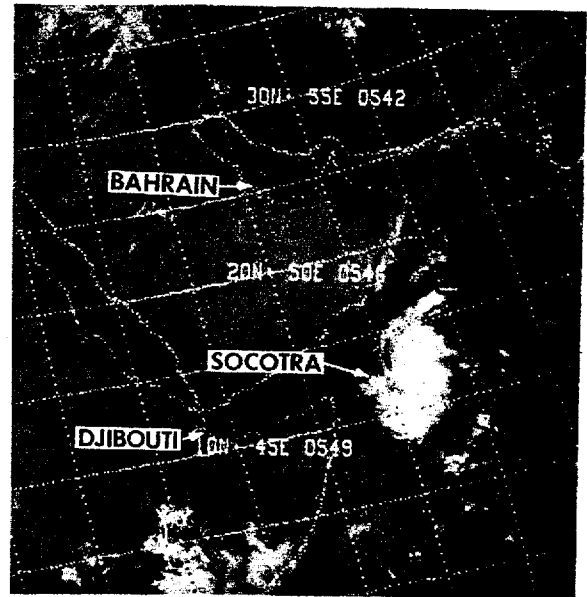


FIGURE 4-49. Tropical Cyclone 25-76 at 50 kt peak intensity 110 nm east of Socotra, 16 October 1976, 0548Z. (NOAA-5 imagery)

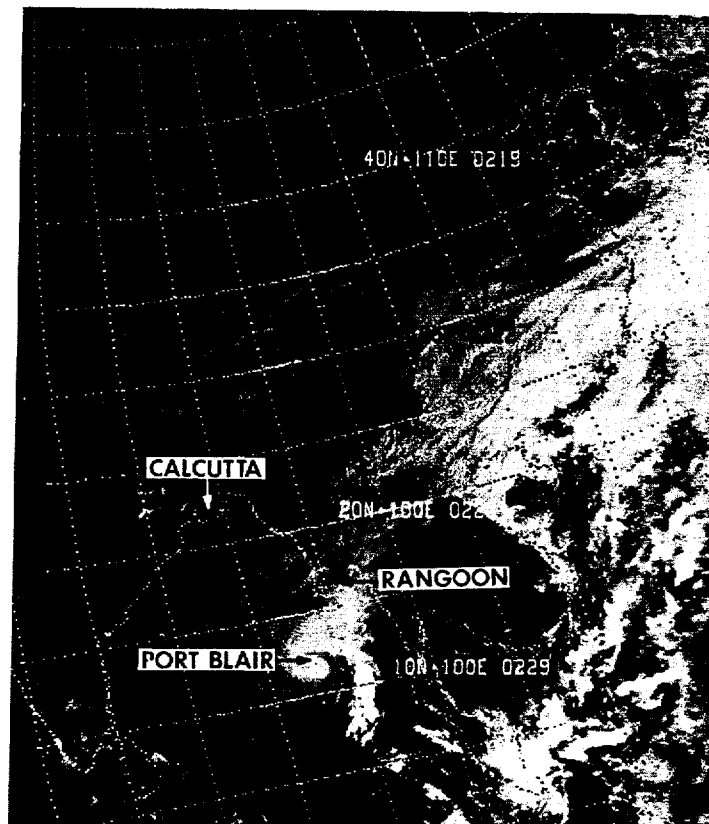
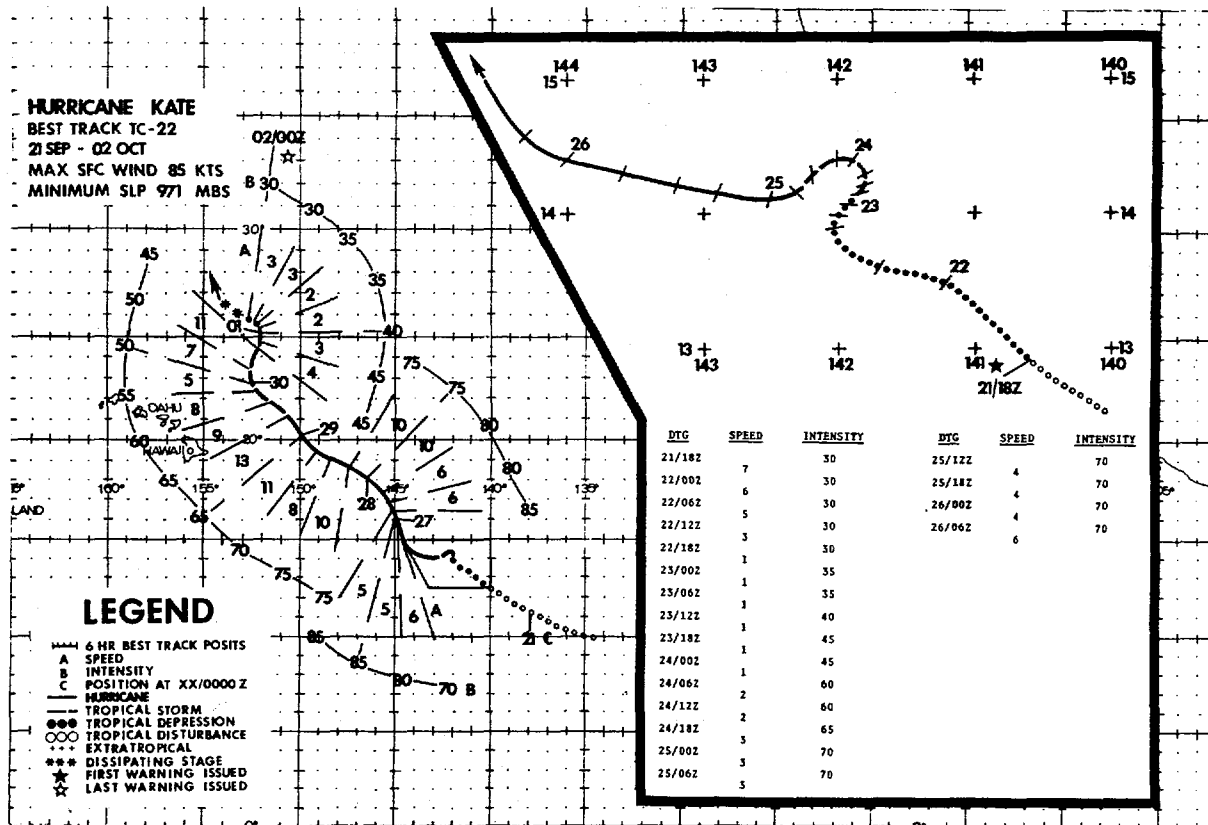


FIGURE 4-50. Tropical Cyclone 30-76 at 55 kt peak intensity 25 nm southwest of Port Blair, 31 December 1976, 0228Z. (NOAA-5 imagery)

5. CENTRAL NORTH PACIFIC TROPICAL CYCLONES



KATE¹

Hurricane Kate, the only hurricane to develop in the Central Pacific during 1976, posed a threat to the Hawaiian Islands before it veered northwestward about a day's distance from the island of Hawaii. Seas generated by the hurricane caused surf up to 15 feet along the northern and eastern shores of Hawaii, Maui and Oahu, but no significant damage was reported.

The storm which was later named Kate was spawned on September 20th in the usually absent Central North Pacific near equatorial trough. Other weak vortices were observed in this trough during the period of Kate but did not develop.

The Central Pacific Hurricane Center issued the first bulletin on TD 22 on the morning of the 21st. A ship, URFJ, reported 30 kt southwest winds 150 nm southwest of the center of the tropical depression.

The depression's previous northwest track stopped on the morning of the 22nd and the storm gradually intensified, becoming Hurricane Kate on the morning of the 24th, very near its position 48 hours earlier. Kate then slowly travelled westward for a day before sharply veering north-northwestward.

On the evening of the 25th, a ship, ATAY, about 120 nm south of Kate, reported 25 kt west winds indicating that the strong winds in Kate were tightly wound near its center. Attaining maximum winds of 85 kt on the afternoon of the 26th 600 nm east-southeast of Hawaii, Kate did not appear an immediate threat to the Hawaiian Islands (Fig. 4-51). However, by the following day it had turned northwest, and on the morning of the 28th was positioned only 330 nm due east of Hawaii. It was then expected to pass 150 nm northeast of the island.

However, during the 28th Kate veered slightly to the right of its expected path and passed harmlessly, 240 nm east-northeast of Hilo, Hawaii while it gradually weakened (Fig. 4-52). Kate finally turned north as a weak tropical storm and ended its career near 27N 154W as the upper air westerlies sheared its clouds and circulation.

¹Extracted from report submitted by Meteorologist in Charge, NWS Forecast Office Honolulu, Hawaii.

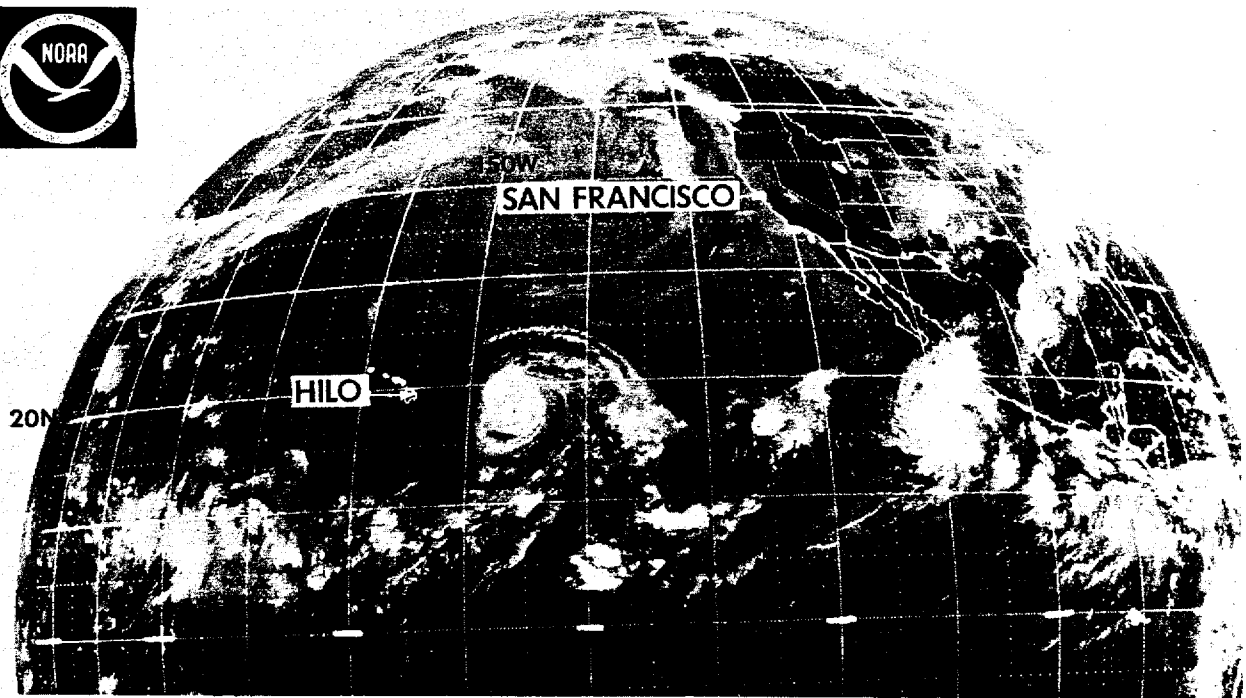


FIGURE 4-51. Hurricane Kate (center) with 80 kt intensity 550 nm east-southeast of Hilo, Hawaii, while Hurricane Liza parallels the coast of Mexico, 27 September 1976, 1745Z. (SMS-2 imagery, Courtesy NOAA)

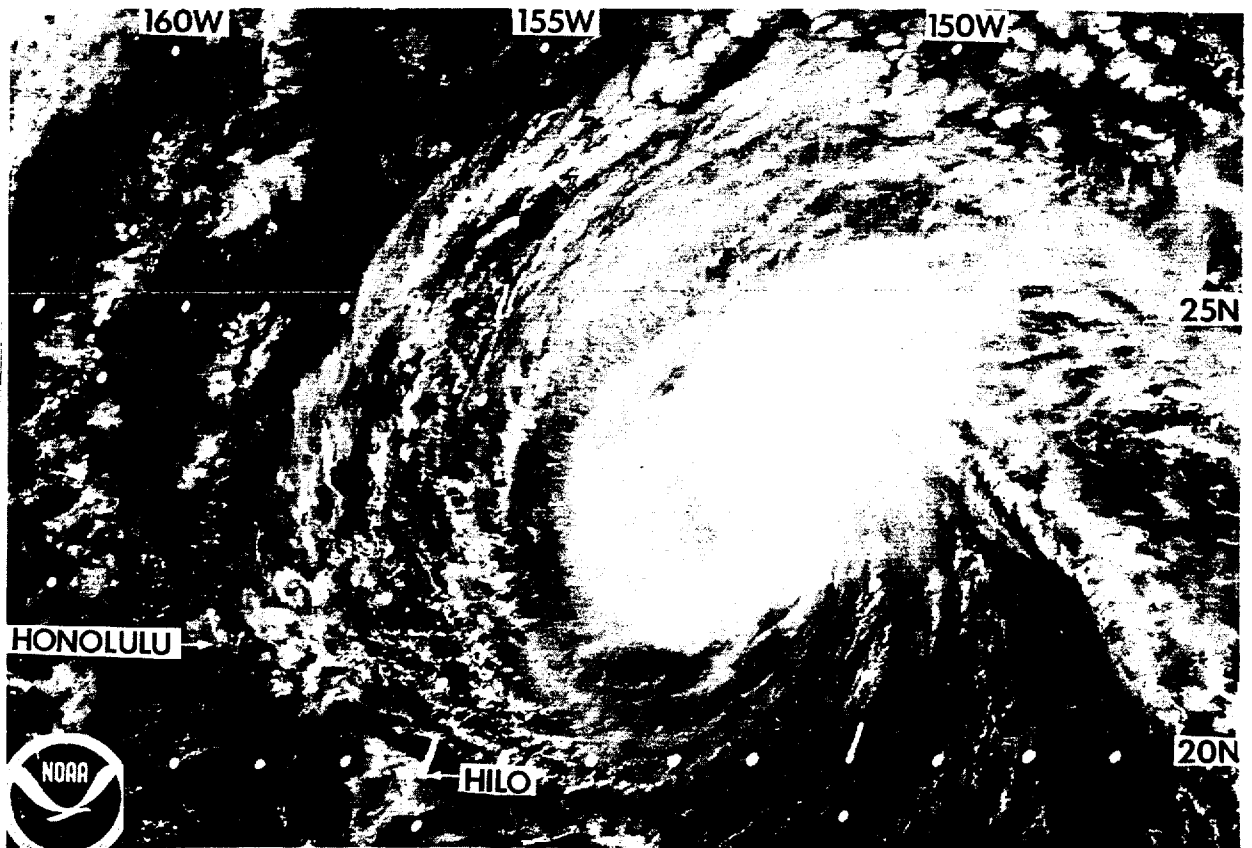


FIGURE 4-52. Kate at 55 kt 230 nm northeast of Honolulu, 29 September 1976, 2015Z. (SMS-2 imagery, Courtesy NOAA)

6. TROPICAL CYCLONE CENTER FIX DATA

Fix data for 1976 will be published in a separate Technical Note. This Tech Note will include fix data for all storms in the PACOM area west of 140W and north of the equator. To obtain a copy of this report write:

Commanding Officer
Fleet Weather Central/JTWC
COMNAVMARIANAS Box 12
FPO San Francisco 96630